Compilation of Geospatial Data for the Mineral Industries and Related Infrastructure of Latin America and the Caribbean

Open-File Report 2017–1079

U.S. Department of the Interior
U.S. Geological Survey

Compilation of Geospatial Data for the Mineral Industries and Related Infrastructure of Latin America and the Caribbean

By Michael S. Baker, Spencer D. Buteyn, Philip A. Freeman, Michael H. Trippi, and Loyd M. Trimmer III

Prepared in cooperation with the Inter-American Development Bank

Open-File Report 2017–1079

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
William H. Werkheiser, Acting Director

U.S. Geological Survey, Reston, Virginia: 2017

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit http://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit https://store.usgs.gov.

Suggested citation:
Baker, M.S., Buteyn, S.D., Freeman, P.A., Trippi, M.H., and Trimmer, L.M., III, 2017, Compilation of geospatial data for the mineral industries and related infrastructure of Latin America and the Caribbean: U.S. Geological Survey Open-File Report 2017–1079, 87 p., 1 geodatabase and 1 geospatial PDF map, https://doi.org/10.3133/ofr20171079.

ISSN 2331-1258 (online)

Preface

This report describes the U.S. Geological Survey's ongoing commitment to its mission of understanding the nature and distribution of global mineral commodity supply chains by updating and publishing the georeferenced locations of mineral commodity production and processing facilities in Latin America and the Caribbean. The geodatabase and geospatial data layers described in this report create a new geographic information product in the form of a geospatial portable document format (PDF) map.

The material in this publication does not imply the expression of any opinion on the part of the Inter-American Development Bank (IDB) or the U.S. Geological Survey (USGS) concerning the legal status of any country, territory, city, or area or of its authorities, or concerning delimitations of its frontiers or boundaries, including disputed terrestrial or maritime claims. Moreover, the views expressed do not necessarily represent the decision or policy of IDB.

The contributions by non-USGS authors in this compilation, including geospatial data obtained from foreign governmental agencies or non-governmental organizations, are published as they were obtained. There may be more data in original datasets than presented in this compilation. The USGS makes no warranty, expressed or implied, concerning the accuracy of information contained in geographic data from non-USGS sources. Neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of these non-USGS data.

Acknowledgments

This report was sponsored by the Transparency Trust Fund of the Inter-American Development Bank (IDB), as part of the Bank's Extractive Sector Initiative (ESI), through the technical cooperation project entitled "Promoting Transparency and Sustainability in the Extractive Sector" (RG–T2496). On the basis of a Cooperative Research and Development Agreement (CRADA) signed by the IDB and the U.S. Geological Survey (USGS), the USGS has undertaken the project entitled "Compilation of geospatial data for the mineral industries and related infrastructure of Latin America and the Caribbean."

Contents

Figures

Tables

Conversion Factors

International System of Units to U.S. Customary Units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
kilogram (kg)	2.2046	pound avoirdupois (lb)
metric ton (t)	1.1023	short ton
	Volume	
cubic meter (m^3)	6.2898	barrel (bbl; petroleum, 1 bbl=42 gallons)
cubic meter (m^3)	35.3147	cubic foot (ft^3)

U.S. Customary Units to International System of Units

Multiply	By	To obtain
	Volume	
barrel (bbl; petroleum, 1 bbl=42 gallons)	0.1590	cubic meter (m^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)

Datum

Horizontal coordinate information is referenced to the World Geodetic System of 1984 (WGS 84).

Abbreviations

BCM	billion cubic meters
CAP	Clarendon Alumina Production
CFN	Companhia Ferroviária do Nordeste / Northeastern Railway Company
CVRD	Companhia Vale do Rio Doce / Vale do Rio Doce Company
DCW	Digital Chart of the World
DEM	digital elevation model
DOI	U.S. Department of the Interior
DOS	U.S. Department of State
ECLAC	Economic Commission for Latin America and the Caribbean
EEZ	exclusive economic zone
EFVM	Estrada de Ferro Vitória a Minas / Vitória-Minas Railway
ENUD	estimated number of deposits
FA	Ferrocarriles Argentinos S.A. / Argentine Railroads
FCA	Ferrovia Centro-Atlantica S.A. / Atlantic Central Railroad
GDP	gross domestic product
GIS	geographic information system
GOR	gas-to-oil ratio
Gt	billion metric tons
IDB	Inter-American Development Bank
IEPD	International exploration and production database (IHS Markit)
IHS	Information Handling Services
JBI	Jamaica Bauxite Institute
JBM	Jamaica Bauxite Mining
LAC	Latin America and the Caribbean
LNG	liquefied natural gas
LSIB	Large-Scale International Boundary
LT1	less than one unit
MCM	million cubic meters
Mt	million metric tons
MW	megawatt
NA	data not available or not applicable
Neth.	The Netherlands
NGA	National Geospatial-Intelligence Agency (U.S.)

NGL	natural gas liquids
NMIC	National Minerals Information Center (U.S. Geological Survey)
PDF	portable document format
RFFSA	Rede Ferroviária Federal S.A. / Federal Railroad Network
RPP	recoverable proven plus probable resources
TOE	total oil equivalent
U.K.	United Kingdom
U.S.	United States
USAID	U.S. Agency for International Development
USGS	U.S. Geological Survey
W	data withheld to protect proprietary information
WPI	World Port Index

Compilation of Geospatial Data for the Mineral Industries and Related Infrastructure of Latin America and the Caribbean

By Michael S. Baker, Spencer D. Buteyn, Philip A. Freeman, Michael H. Trippi, and Loyd M. Trimmer III

Introduction

The U.S. Geological Survey (USGS) compiles information on the location of mineral commodity extraction and processing facilities and analyzes their distribution worldwide to further understand the spatial characteristics of mineral commodity supply chains. The extractive mineral industries, including both fuel and nonfuel mineral commodities and resources, consist of any operations that remove aggregates, hydrocarbons, metals, and minerals from the earth. Examples of extractive processes used at mines and mineral production sites include oil and gas drilling and extraction, mining, mineral beneficiation and concentration, dredging, and quarrying, with examples of downstream processing facilities including petroleum refineries, metal refineries and smelters, and industrial mineral plants, such as those for cement.

The National Minerals Information Center (NMIC) of the USGS collects, analyzes, and disseminates information on a monthly, quarterly, and annual basis for more than 90 nonfuel mineral commodities in more than 180 countries, with information on fuel minerals included in regularly published country profiles. The NMIC performs analytical studies that address topical issues related to the availability of, the supply for, and the domestic and global flows of minerals and mineral commodity products in the global economy. The NMIC also determines the annual U.S. net import reliance on foreign sources of mineral materials to better understand the Nation's economic and strategic requirements.

Past projects by the NMIC have compiled and mapped the overall structure of the mineral industries across major global regions. These reports, beginning in 2006 with USGS Open-File Report 2006–1375 covering Latin America and Canada and USGS Open-File Report 2006–1135 on Africa and the Middle East, have used data from country profiles within the International Area Reports (Volume III) of the annual U.S. Geological Survey Minerals Yearbook, namely, the locations and ownership of specific mines, processing plants (including refineries and smelters), representative oil and gas field center points, and associated petroleum refineries that are representative of the major production and processing facilities in each country (Bernstein and others, 2006; Eros and Candelario-Quintana, 2006). With the publication in 2010 of the regional reports covering Asia and the Pacific (USGS Open-File Report 2010–1254), Northern and Central Eurasia (USGS Open-File Report 2010–1255), and Europe (USGS Open-File Report 2010–1257), the NMIC completed a comprehensive, near-real-time dataset on the structure of the global mineral industry (Almánzar and others, 2010; Baker and others, 2010a–b). Since 2010, NMIC has continued to modernize its digital geospatial data holdings and processing capabilities, allocating additional resources and leveraging geospatial technologies to deliver a more robust range of data products. Information products derived from updates to the global datasets of mineral facilities, as well as commodity-specific studies on the flows of materials through global supply chains, include the following:

- Four reports on the conflict minerals mined in the Democratic Republic of the Congo, covering gold (George, 2015), tantalum (Papp, 2014), tin (Anderson, 2015), and tungsten (Bermúdez-Lugo, 2014);
- An analysis of the impact of the Ebola virus on the minerals industries of countries of West Africa (Bermúdez-Lugo and Menzie, 2015);
- A 60-year retrospective of U.S. net import reliance for nonfuel mineral commodities (Fortier and others, 2015);
- An overview of the minerals industry of Iran in light of the lifting of economic sanctions in 2016 (Hastorun and others, 2016);
- An analysis of resource nationalism in Indonesia (Lederer, 2016); and
- An overview of global stocks of selected mineral-based commodities (Wilburn and others, 2016).

This report reflects NMIC's ongoing commitment to its mission of understanding the nature and distribution of global mineral commodity supply chains by updating and publishing the georeferenced locations of mineral commodity production and processing facilities in Latin America and the Caribbean.

This report also incorporates additional geospatial data layers within a file geodatabase to create a new geographic information product in the form of a geospatial portable document format (PDF) map.[1] This geodatabase and geospatial PDF map include geospatial data on the related physical and economic infrastructure within countries of the region that are required for the extraction and domestic and international trade of mineral resources, as well as additional data layers that highlight exploration and potential areas of future mineral resource extraction and development. Visually comparing the distribution of data across disparate datasets within the multiple data layers of the geospatial PDF map contributes to a deeper understanding of the intersections and complexities of the extractive industries within the region. Some geospatial data layers, such as railroads, electric transmission lines, and oil and gas pipelines, are presented for additional context of the spatial distribution of the related infrastructure of the extractive sector, but this report does not necessarily include detailed attribute information on each related data layer.

Historical background of USGS projects in Latin America and the Caribbean

The USGS has a long history of collaborative scientific projects with the governments of countries within the Latin America and Caribbean (LAC) region. As an objective and unbiased source for scientific information for the general public, government agencies, and private industry, the USGS conducts scientific research that is not in competition with private or State-sponsored industries within foreign countries. The USGS maintains an Office of International Programs which coordinates cooperative research efforts between the USGS and foreign countries and their scientific and geological counterparts or agencies. The Office of International Programs partners with specific mission areas of the USGS to focus on the following:

- Providing information and technical assistance in response to catastrophic geologic events in foreign countries as well as in reducing risks associated with future catastrophic geologic events (such as earthquakes, landslides, land subsidence, sinkholes, tsunamis, and volcanic eruptions);
- Providing technical assistance in the assessment of energy, mineral, and water resources within foreign countries;
- Developing data and information standards and regional data-sharing networks; and
- Conducting worldwide scientific assessments of energy and mineral resources.

Examples of collaborative scientific investigations by the USGS with counterpart agencies include studies conducted in Bolivia and Venezuela, in cooperation with the U.S. Trade and Development Program, to produce mineral resource assessments of the Altiplano region in Bolivia (also known as the Bolivian Plateau) and in the Guyana Shield of eastern Venezuela (U.S. Geological Survey and Servicio Geológico de Bolivia, 1992; U.S. Geological Survey and Corporación Venezolana de Guayana, Técnica Minera, C.A., 1993). The Altiplano investigation presented a comprehensive overview of the geologic setting and detail of the area of interest, with geochemical studies, mineral deposit models, geologic analysis of known mineral deposits, and discussions on the application of economic evaluation models to the deposit models (U.S. Geological Survey and Servicio Geológico de Bolivia, 1992, p. vii). The Guyana Shield investigation presented mineral resource assesments of mineral deposits, covering iron, sedimentary manganese, low-sulfide quartz veins, massive sulfide deposits, and dolomite-marble deposits, among others (U.S. Geological Survey and Corporación Venezolana de Guayana, Técnica Minera C.A., 1993, p. v).

Some examples of mineral-related cooperative projects are listed below in table 1. More geological studies and mineral resource assessments conducted in Latin America and the Caribbean may be found through the USGS Publications Warehouse, located at https://pubs.er.usgs.gov/.

Latin America and the Caribbean—Current regional economic context

The Latin America and Caribbean region includes 33 independent countries and 16 dependencies of foreign governments. Dependencies of the United States—Puerto Rico and the U.S. Virgin Islands—are not included in this report. For some oil and gas data, the Falkland Islands (a British overseas territory that is also known as Islas Malvinas) are included. The Economic Commission for Latin America and the Caribbean (ECLAC) is a part of the United Nations that collects, organizes, and standardizes economic data on the region. Over a 26-year period from 1990 to 2015, ECLAC reported a 111 percent increase in overall annual gross domestic product (GDP) in constant 2015 U.S. dollars for the independent countries[2] for which it had data, increasing from approximately $2,700 trillion in 1990 to $5,700 trillion in 2015. The trend is illustrated in figure 1. In 2015, Brazil accounted for the largest percent share of GDP at 41 percent,

[1]The contributions by non-U.S. Geological Survey (USGS) authors in this compilation, including geospatial data obtained from foreign governmental agencies or non-governmental organizations, are published as they were obtained. Attribute data in original datasets may be more comprehensive in scope than those presented in this compilation. Data produced entirely by non-USGS authors do not necessarily represent the views or position of the USGS or the U.S. Government and are published solely as part of this compilation.

[2]Antigua and Barbuda, Argentina, The Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

Table 1. Examples of mineral-related cooperative projects between the U.S. Geological Survey and counterpart agencies in countries of Latin America and the Caribbean.

[NA, not applicable]

Country	Commodities of interest	Country organization/ agency	Program	Publication reference
Bolivia	Gold, copper, lead, zinc, silver	Servicio Geológico de Bolivia	U.S. Trade and Development Program and U.S. Department of State	U.S. Geological Survey and Servicio Geológico de Bolivia, 1992.
Colombia	Phosphates	Servicio Geológico Nacional and the Inventario Minero Nacional	USGS program, sponsored by the U.S. Agency for International Development (USAID) and U.S. Department of State	U.S. Geological Survey and Servicio Geologico Nacional de Colombia, 1969.
Costa Rica	Gold, copper, lead, zinc, manganese, chromium, and bauxite	Dirección General de Geología, Minas y Hidrocarburos, and the Universidad de Costa Rica	Costa Rican Minerals Reconnaissance Program	U.S. Geological Survey, Dirección General de Geología, Minas y Hidrocarburos, and Universidad de Costa Rica, 1987.
Guyana	Chromium minerals	Geological Survey of Guyana	NA	U.S. Geological Survey and Geological Survey of Guyana, 1976.
Uruguay	Iron and manganese	Dirección Nacional de Minería y Geología (formerly Instituto Geologico del Uruguay)	U.S. Army Mission to Uruguay under the auspices of the Government of Uruguay and USAID	Wallace, 1976.
Venezuela	Iron, manganese, polymetallic systems (copper, lead, zinc, gold, silver), stone, uranium-gold	Corporación Venezolana de Guayana, Técnica Minera, C.A.	NA	U.S. Geological Survey and Corporación Venezolana de Guayana, Técnica Minera C.A., 1993.

followed by Mexico, Argentina, Colombia, and Chile, at 21 percent, 8 percent, 6 percent, and 5 percent, respectively. The entire Caribbean sub-region accounted for 1 percent of GDP. Mining and mining-related activities accounted for 5 percent of the total GDP in 2015, up from 2 percent in 1990, at 2015 prices (the most recent historical price valuation data available for the mining sector) (Economic Commission for Latin America and the Caribbean, 2017).

Still negatively affected by the global economic downturn that began in 2008–09 and the decline in both fuel and nonfuel mineral commodity prices over intervening years, the region has been impacted by external market forces that have reduced demand for mineral commodities since early 2012, most notably by the reduction in demand from China for copper and iron ore (Seth, 2016). However, some mineral-related activities in the region continued to be robust, with exploration and development of mining for gold accounting for 60 percent of all deposits explored in 2012 (Wacaster and others, 2014). Lack of infrastructure within the region poses a great challenge to future extractive industry development. Willis Towers Watson, a global risk advisory organization, estimated that Latin American countries will need to re-invest 9 percent of GDP toward infrastructure projects until 2020 to remain competitive with other global regions such as Southeast Asia (Campbell, 2013). In 2016, ECLAC reported a decline of 9.1 percent in foreign direct investment within the region, constituting the lowest level since 2010, and closely tied to the natural resource sectors of hydrocarbons and mining (Economic Commission for Latin America and the Caribbean, 2016).

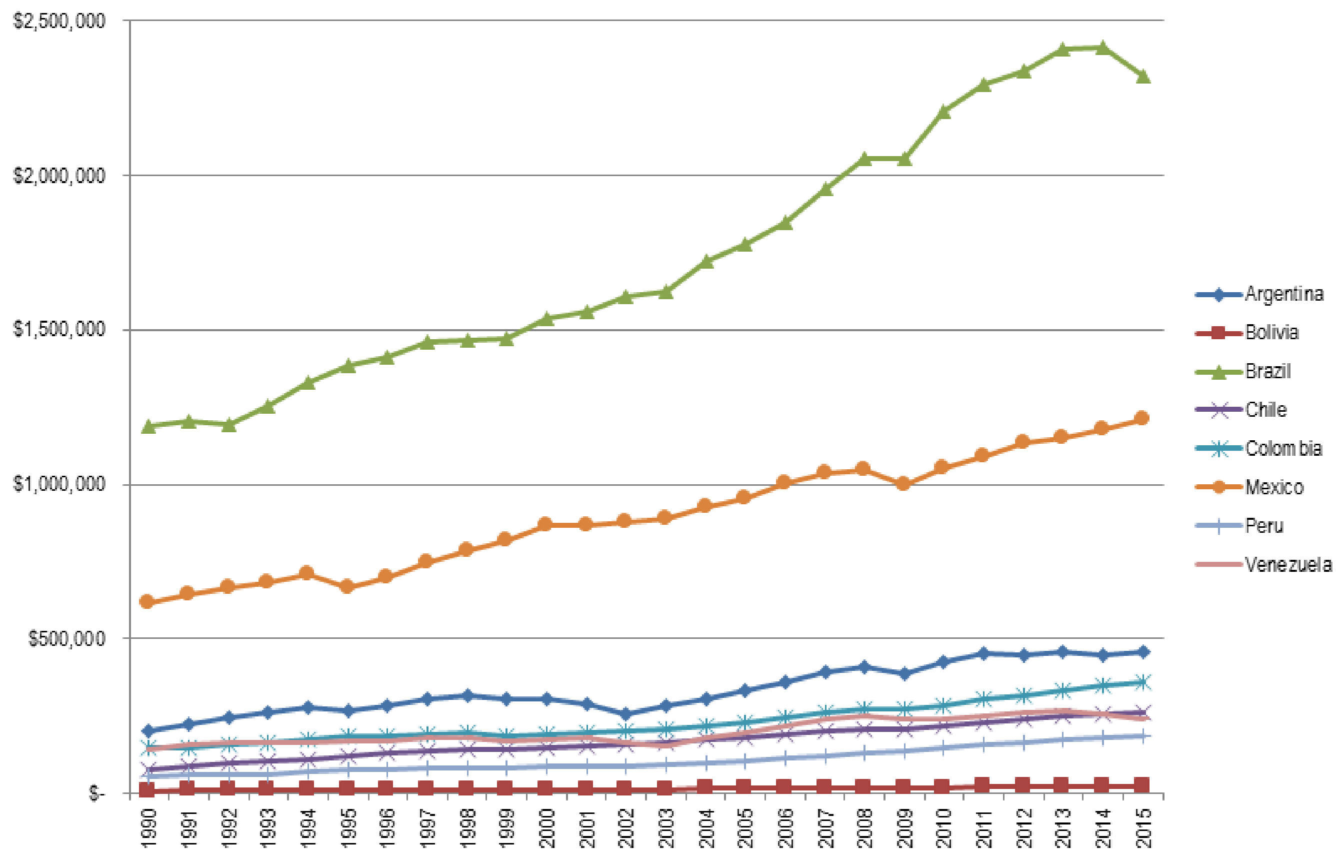


Figure 1. Annual GDP in constant (2015) million U.S. dollars for selected countries in Latin America and the Caribbean, 1990–2015 (Economic Commission for Latin America and the Caribbean (ECLAC), 2017).

Overview of current regional mineral production and reserve estimates

Major mineral producers of the region include Argentina, Brazil, Bolivia, Chile, Mexico, and Peru, with significant production of metallic mineral resources occurring throughout the American Cordillera from Mexico to Chile. Several of these countries have been among the world's top five leading producers of several nonfuel mineral commodities since the late 2000s by both mine production tonnage and value: Brazil for kaolin, niobium-columbium, tantalum, and iron ore, as well as accounting for a third of the global supply of bauxite; Chile for copper, iodine, lithium, and rhenium, in addition to being a major producer of boron and molybdenum; Bolivia for antimony; Mexico for barite, bismuth, fluorspar, gypsum, silver, strontium, and wollastonite; and Peru for copper, gold, lead, silver, tin, and zinc. Colombia is a major producer of coal whereas Mexico and Venezuela produce globally significant amounts of crude petroleum.

Table 2 shows the total percentage of global production per mineral commodity for several of the region's largest producers (Anderson, 2016a–d; Bedinger, 2016; Bray, 2016a–b; Brininstool, 2016; Corathers, 2016; Crangle, 2016; Gambogi, 2016; George, 2016a–b; Guberman, 2016b; Jasinski, 2016a–b; Jaskula, 2016; Kuck, 2016; McRae, 2016a–b; Olson, 2016; Papp, 2016a–b; Polyak, 2016a–b; Schnebele, 2016; Shedd, 2016; Tolcin, 2016; Tuck, 2016).

Based on reserve estimates for 2015, the LAC region contains globally significant reserves for niobium (columbium), lithium, and rhenium, at 95 percent (Brazil), 54 percent (Chile), and 52 percent (Chile) of the global reserves, respectively. Brazil contains 36 percent and 31 percent, respectively, of the global reserves of tantalum and graphite, while Chile contains 29 percent and 21 percent, respectively, of the global reserves of copper and selenium. Peru contains 21 percent and 13 percent of the global reserves of silver and zinc, respectively. Table 3 highlights the countries in the region that rank among the top three countries globally for containing

Table 2. Globally significant nonfuel mineral commodity-producing countries in Latin America and the Caribbean, showing mineral commodity, 2015 preliminary production estimate by country, 2015 preliminary global production, and country production as percent share of global production.

[Data from individual chapters of the USGS's Mineral Commodity Summaries, 2016. Production type is annual mine production for all mineral commodities except molybdenum, the production type of which is unknown. Units are thousand metric tons of metal content or industrial mineral, except where otherwise noted]

Country	Commodity	Country preliminary 2015 production (thousand metric tons)	Global preliminary 2015 production (thousand metric tons)	Country percent of global production
Brazil	Niobium (Columbium)	50	56	89
Chile	Iodine	20	30.3	66
Chile	Rhenium	26,000 kilograms of rhenium content	46,000 kilograms of rhenium content	57
Chile	Lithium	11.7	32.5	36
Chile	Copper	5,700	18,700	31
Mexico	Silver	5.4	27.3	20
Chile	Molybdenum	49	267	18
Mexico	Fluorspar	1,110	6,250	18
Peru	Silver	3.8	27.3	14
Brazil	Iron ore	428 million metric tons gross weight	3,320 million metric tons gross weight	13
Brazil	Bauxite	35,000	274,000	13
Brazil	Tantalum	150 metric tons of tantalum content	1,200 metric tons of tantalum content	13
Peru	Zinc	1,370	13,400	10
Chile	Boron	580	5,960	10
Peru	Copper	1,600	18,700	9
Argentina	Boron	500	5,960	8
Peru	Tin	22.5	294	8
Bolivia	Tin	20	294	8
Peru	Molybdenum	18.1	267	7
Brazil	Graphite	80	1,190	7
Peru	Lead	300	4,710	6

mineral reserves of nonfuel mineral commodities as of 2015 (Anderson, 2016a–d; Bedinger, 2016; Bray, 2016a–b; Brininstool, 2016; Corathers, 2016; Crangle, 2016; Gambogi, 2016; George, 2016a–b; Guberman, 2016a; Jasinski, 2016a–b; Jaskula, 2016; Kuck, 2016; McRae, 2016a–b; Olson, 2016; Papp, 2016a–b; Polyak, 2016a–b; Schnebele, 2016; Shedd, 2016; Tolcin, 2016; Tuck, 2016).

Table 1–1 in appendix 1 includes complete 2015 reserve estimates as well as 2014 annual production and 2015 preliminary production estimates for LAC countries included in the USGS's 2016 Mineral Commodity Summaries, including those commodities with significant global reserves that do not rank in the top three among mineral commodity. Note: the reserves and production data from the Mineral Commodity Summaries are not within the geodatabase or visualized in the geospatial PDF map, but are provided in appendix 1 of this report for reference.

Overview of the file geodatabase—*LAC_Indust_Infra.gdb*

Geodatabase structure and overview of geospatial PDF map

Overview of the file geodatabase—*LAC_Indust_Infra.gdb*

The primary goal of this project was to compile a range of geospatial data layers that contribute to the analysis of the extractive fuel and nonfuel mineral industries and the related economic and physical infrastructure that are integral for the successful operation of the mineral industries

Table 3. Countries ranking among the top three globally per nonfuel mineral commodity reserve estimate in Latin America and the Caribbean for 2015, by global rank and alphabetically by mineral commodity and country.

[Data are from the USGS's Mineral Commodity Summaries, 2016. Units are million metric tons of metal content or industrial mineral, unless otherwise specified. >, greater than; kg, kilogram]

Country	Mineral commodity	2015 country reserve estimate (million metric tons)	Global rank	2015 global reserve estimate (million metric tons)	Country percent of global reserve estimate
Chile	Copper	210	1	720	29
Chile	Lithium	7,500 metric tons of lithium content	1	14,000 metric tons of lithium content	54
Brazil	Niobium (columbium)	4.1	1	>4.3	95
Chile	Rhenium	1,300,000 kg of rhenium content	1	2,500,000 kg of rhenium content	52
Peru	Silver	120,000 metric tons of silver content	1	570,000 metric tons of silver content	21
Peru	Tellurium	3,600 metric tons of tellurium content	1	25,000 metric tons of tellurium content	14
Mexico	Fluorspar	32	2	250	13
Brazil	Graphite	72	2	230	31
Chile	Iodine	1.8	2	75	24
Brazil	Nickel	10	2	79	13
Brazil	Rare earths	22 (rare-earth oxide (REO) equivalent)	2	130	17
Chile	Selenium	25,000 metric tons of selenium content	2	120,000 metric tons of selenium content	21
Brazil	Tantalum	36,000 metric tons of tantalum content	2	>100,000 metric tons of tantalum content	36
Bolivia	Antimony	0.31	3	2	16
Brazil	Bauxite	2.6 (dry)	3	28	9.3
Cuba	Cobalt	0.5	3	7.1	7
Peru	Copper	82	3	720	11
Brazil	Iron ore	23,000 (gross weight of crude ore)	3	190,000 (gross weight of crude ore)	12
Chile	Molybdenum	1.8	3	11	16
Brazil	Tin	0.7	3	4.8	15
Peru	Zinc	25	3	200	13

within the region and the transporation of mineral products across domestic and global markets. An Esri[3] ArcGIS file geodatabase, *LAC_Indust_Infra.gdb*, was constructed to allow for centralized data management of the geospatial data layers. Additional sections of this report go into further detail discussing the individual data layers (also called feature classes), their methodologies and data sources, as well as their broader analytical context. Comprehensive metadata are available for this geodatabase which, in addition to this report, explain any user-defined attribute data contained with any data tables, including any coded values or abbreviations used within data tables.

The geodatabase (*LAC_Indust_Infra.gdb*) is a single Esri file geodatabase that includes seven feature datasets, which contain more than 20 data feature classes that are shown within the geospatial PDF map. New point data feature classes were researched, compiled, and published as separate USGS data releases: mines and mineral processing plant facilities (also referred to as "mineral facilities" broadly), mineral exploration and development sites, and mineral commodity exporting ports (Baker, Bleiwas, and Goonan, 2016; Baker and Buteyn, 2016; Baker and Wilburn, 2016). Additional point data feature classes compiled from other sources

[3]Esri is a software development and services company providing geographic information systems software and geodatabase management applications.

include locations of liquefied natural gas terminals, porphyry copper deposits, and oil and gas field center points. Polyline data feature class examples include oil and gas pipelines, transmission lines, and oil and gas concession leasing areas. Polygon data feature class examples include USGS petroleum provinces and porphyry copper tracts potentially containing polymetallic deposits. A down-sampled 30-meter (m) regional digital elevation model (DEM) is included for generalized topographic reference. This file geodatabase along with its metadata and a map document file in the compressed archive file *LAC_Indust_Infra.zip* are available at https://doi.org/10.3133/ofr20171079. Figure 2 and table 4 show the structure of the file geodatabase, as organized by the seven top-level feature datasets, as well as a top-level raster feature.

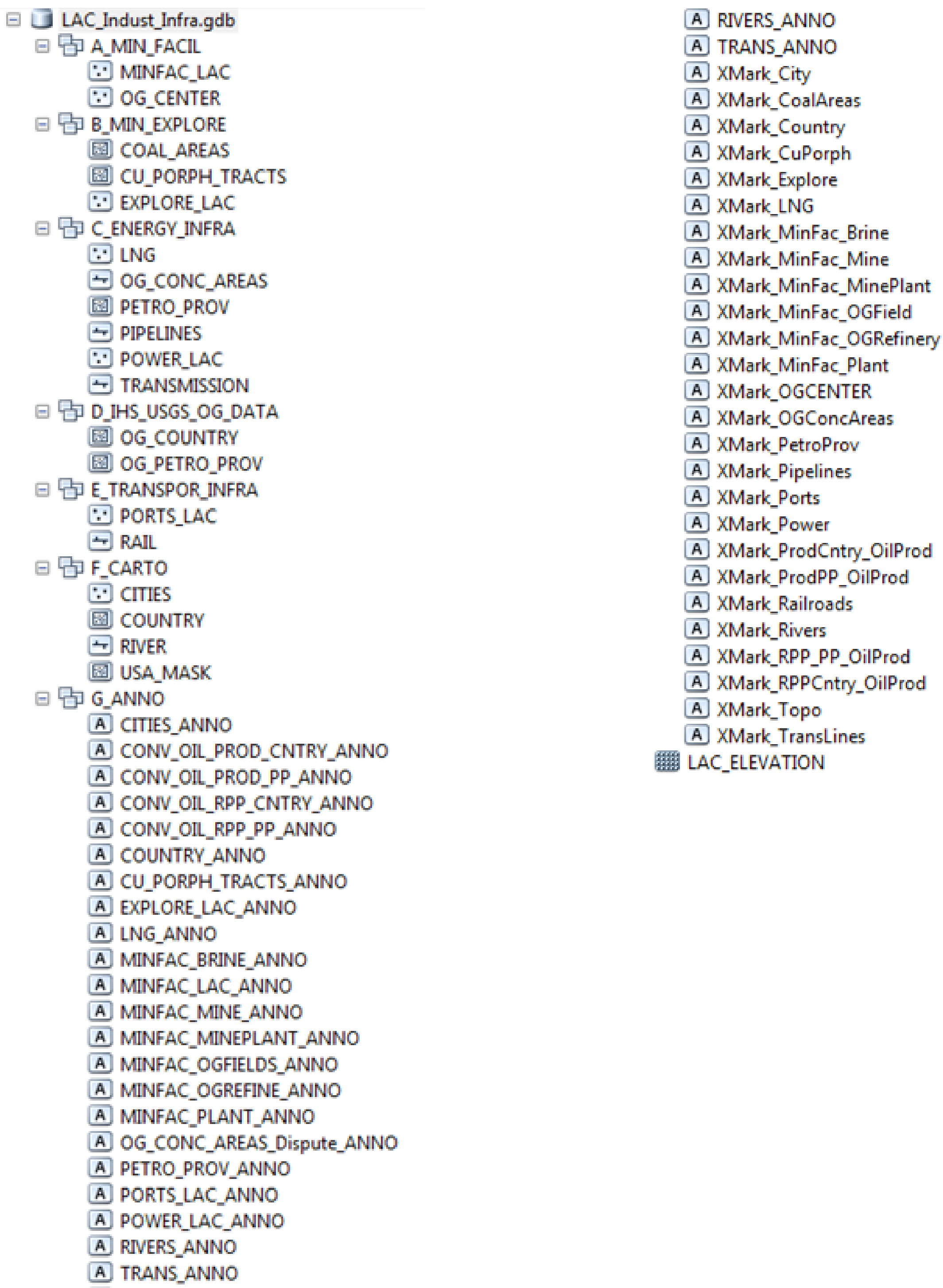


Figure 2. File structure for *LAC_Indust_Infra.gdb* geodatabase.

Table 4. Description of feature datasets within the file geodatabase *LAC_Indust_Infra.gdb* and supporting metadata files, as well as the related data folder name within the geospatial PDF map.

[NA, not applicable]

Geodatabase feature dataset name	Geospatial PDF map folder name	Description
A_MIN_FACIL	Mineral production sites and mineral processing facilities	Mineral facilities (brine operations, mines, concentrators, processing plants, refineries, smelters) and petroleum facilities (oil and gas fields, refineries, petrochemical complexes).
B_MIN_EXPLORE	Mineral exploration sites and mineral resources	Mineral exploration and development sites, areas of coal occurrences, and porphyry copper tracts that were included in USGS Global Assessments for potential undiscovered porphyry copper deposits.
C_ENERGY_INFRA	Energy infrastructure	Manmade physical infrastructure relating to electric power generation and the oil and gas industries, including USGS petroleum provinces, liquefied natural gas terminals, oil and gas concession leasing areas, oil and gas pipelines, electrc power generating facilities, and electric power transmission lines.
D_IHS_USGS_OG_DATA	IHS International Exploration and Production Database (IEPD) and USGS oil and gas data	Hydrocarbon resource data aggregated by geographic areas (either country or petroleum province). Data from the IHS (IEPD) include cumulative production of oil, gas, and condensate, as well as recoverable proven plus probable hydrocarbon resources, for conventional, unconventional, extra-heavy crude resources. Data from the USGS includes undiscovered, technically recoverable resources from oil fields or gas-only fields.
E_TRANSPOR_INFRA	Transportation infrastructure	Manmade physical infrastructure relating to the transportation and shipment of mineral commodities within the region; includes railroads and mineral commodity exporting ports.
F_CARTO	Cartographic elements	Physical and political cartographic base data layers for reference; includes capital cities, other cities, major rivers, and international boundaries.
G_ANNO	Layers have the word “label” and the suffix “Anno” and precede the layer to which they refer	Labels for the geospatial PDF map data layers stored within one geodatabase annotation group feature dataset.
LAC_ELEVATION	Within “F_CARTO—Cartographic Elements”	Raster dataset of a digital elevation model to show physical topographic relief (elevation, in meters) of the region.
Extensible markup language (.xml) files for Federal Geographic Data Committee (FGDC) metadata		
LAC_Indust_Infra_Meta.xml	NA	Metadata for the file geodatabase *LAC_Indust_Infra.gdb*.

Overview of geospatial PDF map layout (layer navigation and visibility)

The geospatial PDF map created for this project contains the feature datasets and their feature classes organized as map layers. Within a PDF reader, such as Adobe Reader, these layers are accessed through a layer navigation pane on the left-hand side of the screen when the PDF file is open (figure 3). For this geospatial PDF map, there is one layer navigation menu for the “LAC Regional Map” layer.

Figure 4 shows a list of the feature dataset folders containing the feature classes, or individual data layers, within the geospatial PDF map. Clicking the “plus” button next to a folder will expand the folder so the folder contents are visible, as in figure 5. Clicking on the eye icon to the left of any individual feature class data layer within a folder turns on or off the visibility of that individual data layer; clicking on the eye icon next to the top-level feature dataset folder turns off visibility of all contents within that folder. If all feature datasets and classes are turned on simulatenously, the map

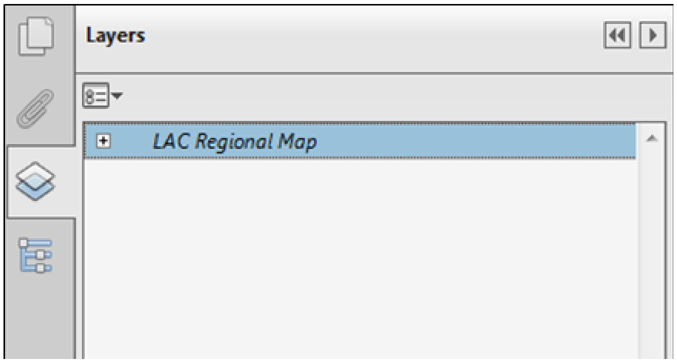


Figure 3. Screenshot of the geospatial PDF map, showing the left-hand layer navigation pane open.

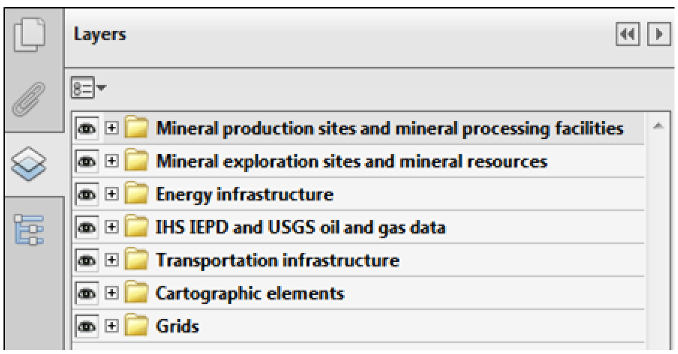


Figure 4. List of feature dataset folders within the geospatial PDF map.

will be illegible due to the number of data layers present and overlapping labels. However, a user may selectively turn on or off different layers and their labels to analyze the spatial relationships between the feature classes. Base cartographic elements that are visible upon opening the geospatial PDF map, such as vector data points for cities, vector polyline data for major rivers or international boundaries, and raster digital elevation model (DEM) data for the topographic relief, can be turned off for clearer visual interpretation of data feature classes. Turning off topographic relief may enhance visual analysis, by showing only the international boundaries.

Attribute data cannot be accessed through this navigation pane. See the following section for information on accessing attribute data with the map. Annotation group layers for labels directly precede the layer they refer to and can be turned on and off separately for better visual clarity between other data layers. A user is able to generate different maps of individual data layers by controlling the visibility of data layers and their labels, which can then be printed out as an individual map. For example, a user could overlay oil and gas field center points with the USGS petroleum provinces to determine which cluster of oil and gas fields is within which specific petroleum province; the user will then have the ability to print out that specific representation.

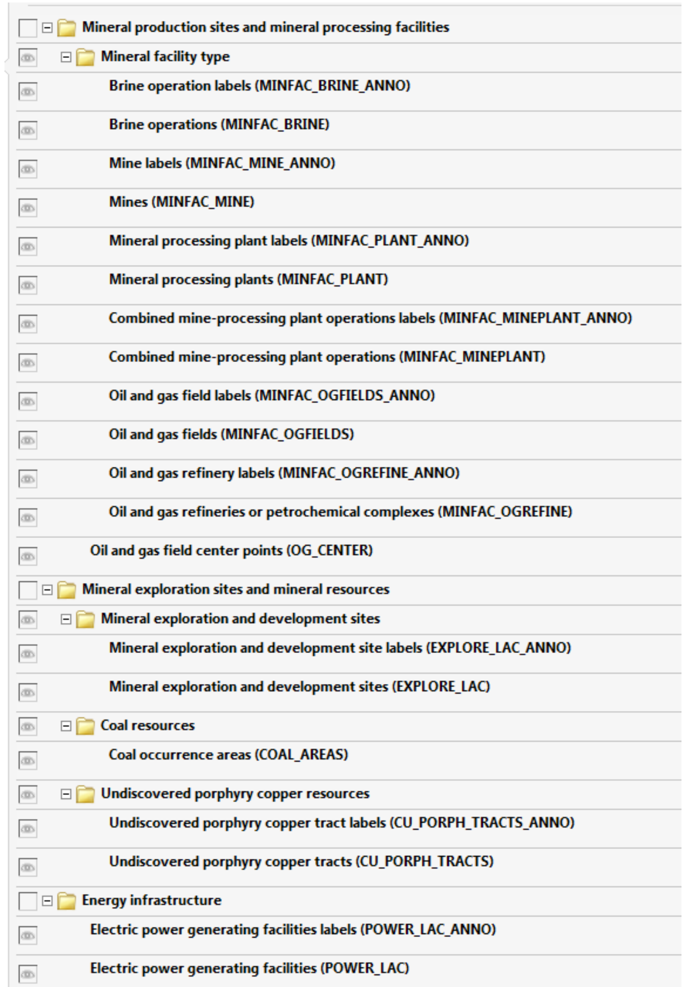


Figure 5. Expanded feature dataset folders showing individual data feature classes, or data layers, associated annotation group layers, or label layers, and the visibility controls within Adobe Reader. Values in parentheses indicate the corresponding feature class in the geodatabase.

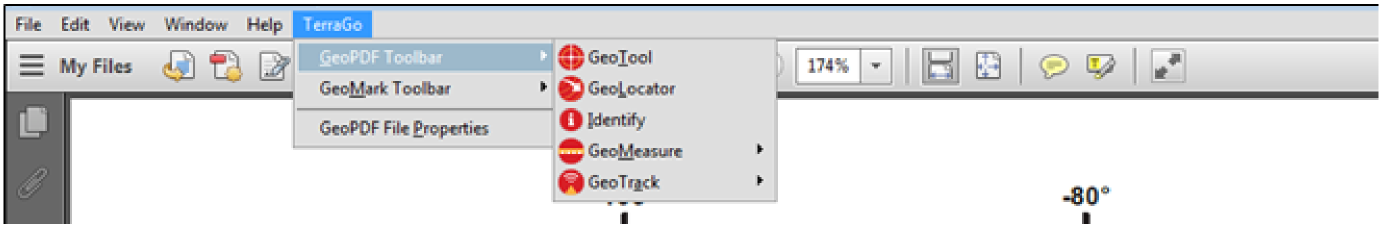


Figure 6. Screenshot of TerraGo Toolbar installed on a computer as a top menu, within Adobe Reader, showing several geospatial tools available for use.

Using the "Identify" and "Search" toolbars to access data feature class attribute data

The geospatial map produced as part of this report is a TerraGo Technologies geospatial PDF map (GeoPDF). The proprietary software that creates this type of a geospatial PDF map allows several of the core functions of the map to work, namely, the ability to export multiple geospatial data layers into a geopackage that supports data queries while the PDF is open in Adobe Reader, as well as advanced file size compression algorithms. A geopackage is a "hidden" SQLite database embedded into the geospatial PDF map. The benefits of this functionality include the ability to generate PDF maps that contain attribute data within the PDF so a user does not have to cross-reference against external data sources. For maximized usage of this map, users may download the latest version of the TerraGo Toolbar, a free plug-in for Adobe Reader and Adobe products, available at http://www.terragotech.com/products/terrago-toolbar.[4]

Upon installation, the TerraGo Toolbar appears as a top menu within Adobe Reader (fig. 6) or as an Extended menu on the right-hand side of the Adobe Reader screen (fig. 7). Both toolbar locations offer the same functionality to the user.

[4]Any use of trade, firm, or product names, including TerraGo Technologies, TerraGo Toolbar, and TerraGo GeoPDF is for descriptive purposes only, to better inform the user of advanced functions presented by this technology, and does not imply endorsement by the U.S. Government.

Using the "Identify" tool

Figure 7 shows the location of the "Identify" tool. This tool enables a user to click on a drawn feature of a feature class, such as a point or polygon, which contains attribute data. Within the "Identify" window a user can see the attribute data associated with that feature. Table 5 shows which geodatabase feature classes and map layers have attribute data within the geospatial PDF map. See specific report sections for those map layers having attributes for which data attribute fields are included. In table 5, the column labelled "additional detailed attribute information included in geodatabase data tables" refers to additional tabular data, beyond geospatial geometry parameters, that may be included, but which are not included in the attribute fields within the map (owing to limitations on total file size for the PDF; excessive attribute data can render the PDF unuseable). Attribute data are packaged into an Open Geospatial-Consortium-compliant Geopackage within the geospatial PDF map; a GeoPackage is a SQLite database that can retain multiple vector features and attributes with efficient drawing capabilities. SQLite is a database engine that allows a SQL-type database to be embedded within a product. Owing to the large amount of attribute information for the mineral facilities within the region, when a user clicks on the "Identify" tool, it may take a while to load, or "hang," especially once the file is first opened; this is normal software behavior.

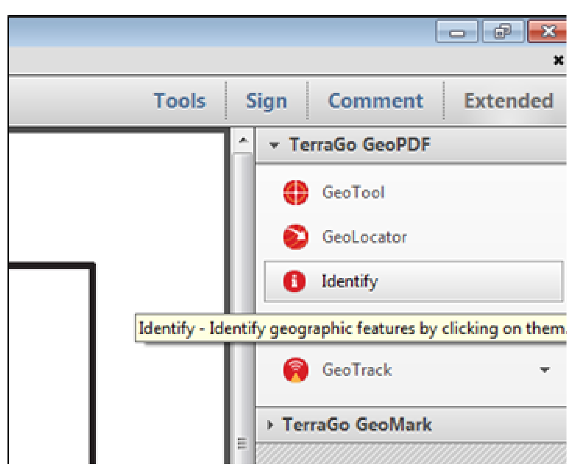


Figure 7. Screenshot of TerraGo Toolbar installed on a computer as an Extended menu on the right-hand side, within Adobe Reader, showing several geospatial tools available for use.

Table 5. Geodatabase feature classes, geospatial PDF map data layers, and included attributes in the geospatial PDF map.

[RPP, recoverable proven plus probable resources; NA, not applicable]

Geodatabase feature class name	Geospatial PDF map and ArcGIS map document (.mxd) data layer name	Attribute information included in geo-spatial PDF map	User-defined attribute field used as map layer label in geospatial PDF map	Additional detailed attribute information included in geodatabase data tables
Feature dataset A_MIN_FACIL – Mineral production sites and mineral processing facilities				
MINFAC_LAC	Mineral facilities, which include the following separate data layers for better display: Brine operations Mines Mineral processing plants Combined mine-plant operations Oil and gas fields Oil and gas refineries and (or) petrochemical complexes	Yes	"FACID"	Yes
OG_CENTER	Oil and gas field center points	No	Not labeled	No
Feature dataset B_MIN_EXPLORE – Mineral exploration sites and mineral resources				
COAL_AREAS	Coal occurrence areas	No	Not labeled	Yes
CU_PORPH_TRACTS	Undiscovered porphyry copper tracts	No	"Tract_name" and "TractID" fields combined. For example, the Sonoran Desert tract has the TractID MX-J2 and is labeled as "Sonoran Desert (MX-J2)."	Yes
EXPLORE_LAC	Mineral exploration and development sites	Yes	"FACID"	Yes
Feature dataset C_ENERGY_INFRA – Energy infrastructure				
LNG	Liquefied natural gas terminals	Yes	"Project_Name"	Yes
OG_CONC_AREAS	Oil and gas concession leasing areas	No	Not labeled	No
PETRO_PROV	USGS petroleum provinces	No	"NAME"	Yes
PIPELINES	Oil and gas pipelines	No	Not labeled	No
POWER_LAC	Electric power generating facilities	Yes	"FACID"	Yes
TRANSMISSION	Electric power transmission lines	No	Not labeled	No
Feature dataset D_IHS_USGS_OG_DATA – IHS IEPD and USGS oil and gas data				
OG_COUNTRY	Cumulative conventional oil production, by country	Yes	"RANK1"	Yes
OG_PETRO_PROV	Cumulative conventional oil production, by petroleum province	Yes	"RANK1"	Yes

Table 5. Geodatabase feature classes, geospatial PDF map data layers, and included attributes in the geospatial PDF map.—Continued

[RPP, recoverable proven plus probable resources; NA, not applicable]

Geodatabase feature class name	Geospatial PDF map and ArcGIS map document (.mxd) data layer name	Attribute information included in geospatial PDF map	User-defined attribute field used as map layer label in geospatial PDF map	Additional detailed attribute information included in geodatabase data tables
OG_COUNTRY	Conventional oil, RPP, by country	Yes	"RANK2"	Yes
OG_PETRO_PROV	Conventional oil, RPP, by petroleum province	Yes	"RANK2"	Yes
Feature dataset E_TRANSPOR_INFRA – Transportation infrastructure				
PORTS_LAC	Mineral commodity exporting ports	Yes	"PORTNAME"	Yes
RAIL	Railroads	No	Not labeled	No
Feature dataset F_CARTO – Cartographic elements				
CITIES	Capital and other cities	No	"NAME"	Yes
COUNTRY	International boundaries	No	"NAME"	No
RIVERS	Major rivers	No	"NAME"	No
USA	United States	Not in project study area; grayed out and shown for reference	Not labeled	No
LAC_ELEVATION	Topographic relief	No	Not labeled	NA
Feature dataset G_ANNO – Annotation group				

48 annotation group label layers as individual feature class (not listed here).

Two categories are included: (i) annotation group label layers for data layers and (ii) annotation group layer using an "X" to indicate which layer is visible in the geospatial PDF map in the upper right-hand corner of the map.

In the map document table of contents and geospatial PDF map, label layers precede the data layer to which they refer and have the word "label" in the layer title. In the geodatabase, these layers are indicated with the suffix "ANNO."

In the map document table of contents, the visibility indicator layers have the prefix "XMark_" and precede the data layer to which they refer. In the geodatabase, these layers follow the same format, with the prefix "XMark_." In the geospatial PDF map, these "XMark_" layers are not visible at all and are instead part of the data layer itself.

The "Identify" feature works best at 100 percent zoom level for the entire document. One software limitation to this tool is that increasing the document zoom level to 200 percent or higher causes the crosshair target to have a more difficult time selecting the feature. Point features should be clicked nearest to the center of the symbol icon on the map document. If multiple feature classes are shown at the same time, it may be necessary to turn off any other feature classes to avoid inadvertently selecting a different feature. There is no option to select all objects within a polygon search area by dragging the cursor over drawn symbols. On older computers, or for users working with an older version of Adobe Reader, the "Identify" feature may hang or load slowly between different feature selections, or may not be functional. Table 6 shows which feature class attribute fields are included in the geospatial PDF map for general reference. See additional sections of this report for a detailed discussion of each of these attribute fields and their values.

Table 6. List of attribute fields included in the geospatial PDF map, by data feature class.

Geodatabase feature class name	Attribute fields included in the geospatial PDF map
MINFAC_LAC	FACID, COUNTRY, COMMODITY, MIN_PROD, LOCDESC, LOCNAME, FACTYPE, OPERATOR, ANNCAP, UNITS, COMBOCAP, STATUS, LOCACC
POWER_LAC	FACID, COUNTRY, PLANTNAME, CAPACITY_MW, ENERGY_TYPE
LNG	FACID, COUNTRY, PROJECT_NAME, LOCATION_DESCRIPTION, TYPE, OWNERS
PORTS_LAC	FACID, PORTPRODID, MULTI_REC, COUNTRY, PORTNAME, COMM_EXPD, FORM_COMM, EST_ANN_TONNAGE, DEST, FEED_SOURCE
EXPLORE_LAC	FACID, COUNTRY, PROJTYPE, PROJNAME, COMM
OG_COUNTRY	COUNTRY, CONV_OILFLD For cumulative production of conventional oil: CONV_OILCM_MCM, CAT 1, RANK 1 For recoverable proven plus probable conventional oil resources: CONV_OILRPP_MCM, CAT 2, RANK 2
OG_PETRO_PROV	USGS_PP_CODE, USGS_PP_NAME, CONV_OILFLD For cumulative production of conventional oil: CONV_OILCM_MCM, CAT 1, RANK 1 For recoverable proven plus probable conventional oil resources: CONV_OILRPP_MCM, CAT 2, RANK 2

Using the “Search” function within the “Identify” tool

Within the “Identify” tool window, a search bar is located immediately at the top (figure 8). This search bar allows for character string-based searches within relevant feature classes. A character string refers to any combination of text or numeric characters that could be a stand-alone defined word or only a portion of a word. Similarly to the potential for lag-time on loading the “Identify” tool, the “Search” function may pause when performing queries that return multiple results; for example; a search for “gold” returns 233 results across the “MINFAC_LAC,” “EXPLORE_LAC,” and “PORTS_LAC” feature classes.

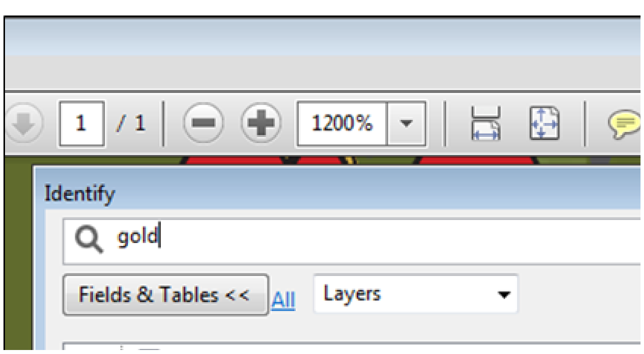


Figure 8. Screenshot of the “Identify” window, showing the “Search” function.

The visibility of a data layer is irrelevant to the “Search” function, meaning that data layers that are turned off are also searchable, depending on the input string. The “Search” parameters are inclusive; for example, a string of “tin” would return mineral facility records that have the string “tin” anywhere in any data field, including both mineral commodity records for the element tin and records of the country of Argentina.

Figure 9 shows an example of the results of the “Search” function with the mineral commodity exporting ports feature class, labelled as “Ports” in the map document. A user can click through the results list to see the attribute information per data record.

The software is limited to exact string inputs. So for example, searching for “gold, Bolivia,” will not return all gold records within Bolivia. In this case, the program will be searching for anything that exactly matches “gold, Bolivia,” which in the context of this project, is an unlilely combination of search terms. Users will have better results with broad and simple searches for specific locations, such as a city or port name, or for a specific mineral commodity (“lithium”) or form of a mineral commodity (“lithium hydroxide”). This software plug-in does not have the full functionality of more robust database querying capabilities, including multiple string searches. Figure 10 shows when search results are returned from multiple data layers; a user has the option to scroll through multiple results and expand or collapse coverage from multiple layers.

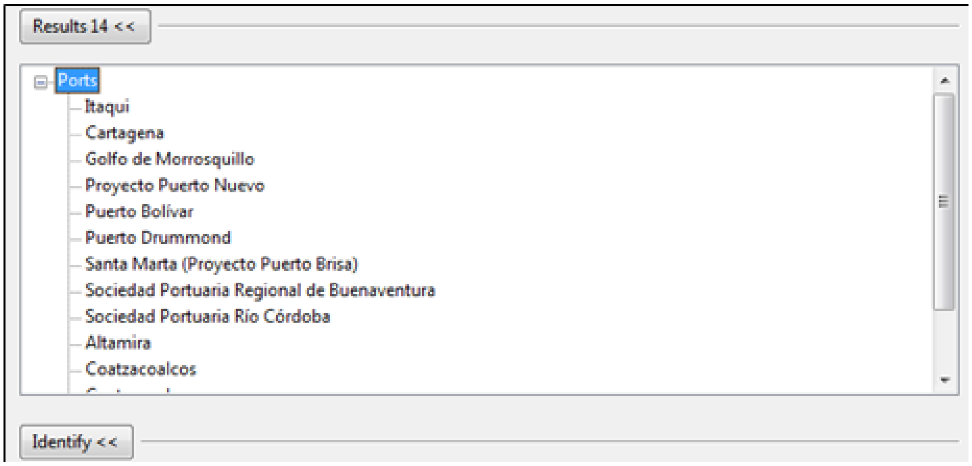


Figure 9. Example results after performing a search with the "Search" function within the "Identify" window.

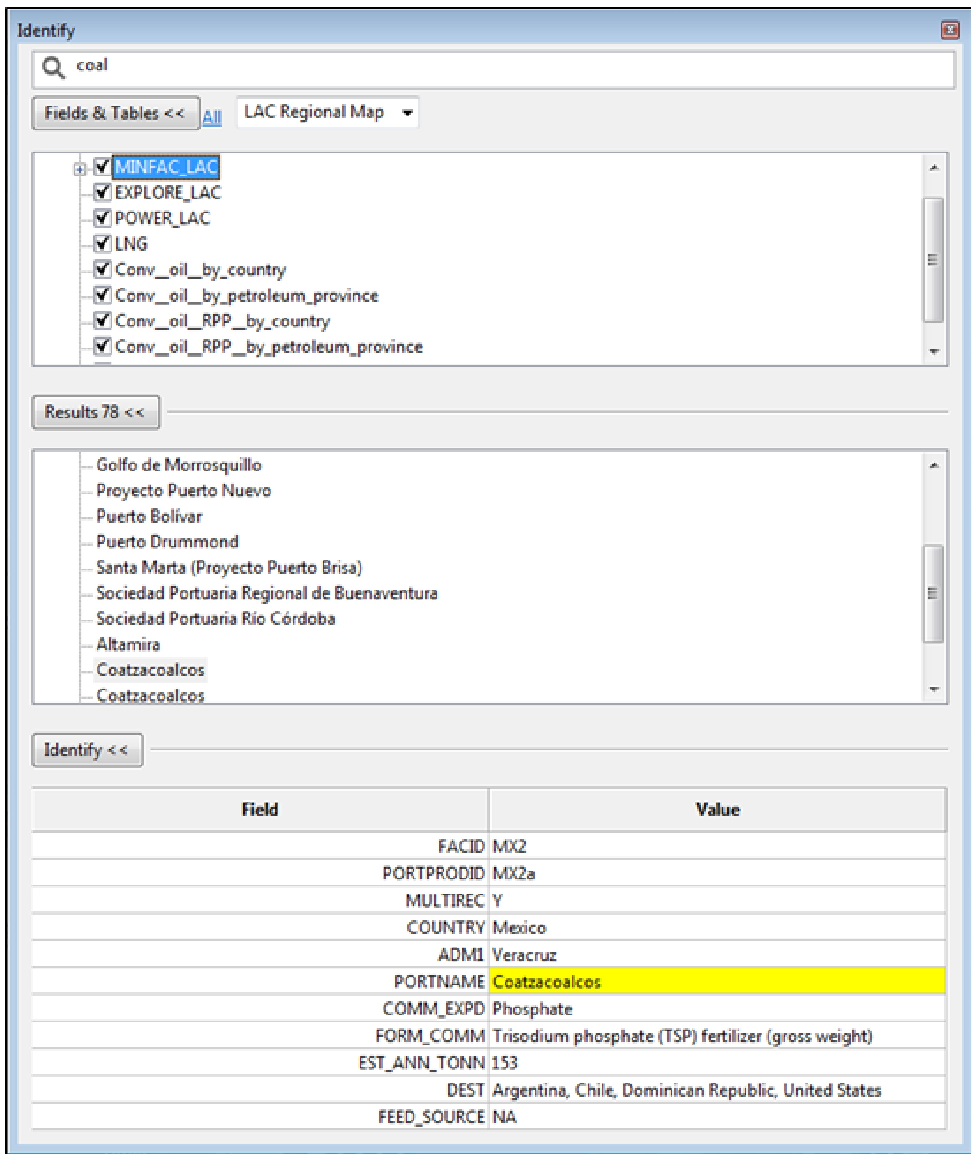


Figure 10. Expanded results of a search with the string "coal." The Fields & Tables tab shows data layers containing a result. The Results tab shows individual data points containing a match with the search query string; the number following the word "Results," 78, indicates the total number of matches. The Identify tab shows individual field values for a data point when that data point is selected in the Results tab. Note that the selection in this example is for a port name (highlighted in yellow) that contains the string "coal" and is not a mineral commodity entry; the software returns any entries that match the text string searched.

Overview of geospatial data layers

Mineral production sites and mineral processing facilities—*A_MIN_ FACIL* feature dataset

The feature dataset *A_MIN_FACIL* contains vector point data covering the mines, mineral processing facilities, oil and gas fields, petroleum refineries, metal refineries and smelters, and similar production and extraction-related geospatial data. Table 7 shows the individual feature classes within this feature dataset.

Mineral facilities: mines and processing facilities—*MINFAC_LAC* feature class

Central to NMIC's mission in understanding global mineral commodity supply chains is the compilation and publication of tables highlighting the structure of the global mineral industry in Volume III of the annual U.S. Geological Survey Minerals Yearbook (https://minerals.usgs.gov/minerals/pubs/country/). This volume is organized by major geographic regions, of which Latin America and Caribbean, along with Canada, are combined as one. Country specialists within NMIC's Global Minerals Analysis Section assemble data into a table which includes the following:

- Mineral commodity and specific forms of mineral commodity products (if known).
- Major operating companies and major equity owners.
- Names and locations of mines and mineral processing facilities.
- Annual capacity per facility for that given mineral commodity or specific form of mineral commodity product.[5]

Locations[6] of facilities are determined from company reports and websites, atlases of mining locations from foreign countries' governments and universities, and a variety of geological and scientific literature and data resources. These tables are not necessarily comprehensive or exhaustive for any one country but generally do contain the major mineral-related facilities within most countries. For example, information and data on the nature and extent of some industrial mineral operations can be difficult to obtain and fully validate; therefore, this data layer may be more heavily skewed toward metals. It is also important to note that oil and gas fields and petroleum-producing areas within this data layer include only those for which NMIC country specialists were able to determine annual capacities; additional oil and gas field center points from other USGS sources are shown in a separate data layer for general spatial reference but do not contain attribute information (see next section).[7]

Table 8 shows the attribute fields contained in the mineral facility data feature class *MINFAC_LAC,* the range of specific field values if applicable, and necessary comments for interpretation of the data. The full mineral facility data feature class, as well as metadata explaining all attribute field values, codes, and abbreviations, is available as a USGS data release (Baker and Buteyn, 2016) through the USGS ScienceBase data release page, available at https://doi.org/10.5066/F7MG7MM6.

In the geospatial PDF map, the six categories of facility types are shown as separate map layers for better understanding of the geographic distribution of the varying kinds of facilities and for improved legibility of the map labels. Labels are shown as separate data layers that have the title format of "MINFAC_[Facility Type]_ANNO," indicating that they belong to the MINFAC data feature class and are

[5]NMIC tracks the annual production capacities of international facilities as opposed to the annual production figure. Data are published to reflect the overall structure of a country's mineral industry from year to year, rather than the specific annual production at individual facilities. Table 1 of each individual country chapter within Volume III presents an overview of annual production within a specific country.

[6]Throughout this report and geodatabase, all locations contain information on the locational accuracy of individual points. "A" represents approximate locations; "E" represents exact locations. Approximate locations may be present owing to several factors, including (1) the nature of the input data point is more suited to a single approximate point, as in the case of aggregated information at a country level, (2) available satellite imagery was too low in resolution for the exact identification of a facility, or (3) conflicting information existed in public sources as to the exact location.

[7]Not all information contained within Volume III of the Minerals Yearbook may be included within the *MINFAC_LAC* feature class, owing to revisions or delayed release of updated country information.

Table 7. Data feature classes within the *A_MIN_FACIL* feature dataset of the file geodatabase *LAC_Indust_Infra.gdb*.

Feature class name	Feature class name in geospatial PDF map	Description
MINFAC_LAC	Mineral facility types	Vector point data. Fuel and nonfuel mineral facilities each a separate map layer: brine, mine, mineral processing plant, mine and plant combined, oil and gas field, oil and gas refinery and (or) petrochemical complex.
OG_CENTER	Oil and gas field center points	Vector point data. Oil and gas field center points derived from the USGS Energy Resources Program publication. Included for visual spatial reference; no attribute data are included in the geodatabase.

Table 8. Description of user-defined attribute fields in the mines and mineral processing facilities feature class *MINFAC_LAC*.

[ID, identification; e.g., for example; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
OBJECTID	Object ID	Numeric (integer)	Unique ID number for each data record object	Sequential order, ascending	No
ROWID	Row ID	Numeric (integer)	Unique ID number for each row from original dataset	Sequential order, ascending	No
GENC_CC	GENC country code	Text	GENC two-digit country code	Unique to each country	No
FACID_NUM	Facility ID number	Numeric (integer)	Unique ID number per facility per country	Sequential order, ascending, restarts for each country.	No
FACID	Facility ID	Alphanumeric	GENC_CC combined with FACID_NUM. Used as labels on map.	Sequential order, ascending	Yes
MULTI_COMM	Multiple commodities	Text	Multiple commodities produced at a single facility	Flagged "Y" to indicate when multiple commodities are produced at a single facility. Example 1: Aguilar Mine in Argentina produces lead and silver concentrates. Example 2: The Vinto smelting complex in Bolivia produces antimony, bismuth, lead, silver, tin, and tin-lead alloys.	No
MULTI_PROD	Multiple products	Text	Multiple products of at least one mineral commodity produced at a single facility	Flagged "Y" to indicate when multiple products of at least one mineral commodity are produced at a single facility. Example 1: The ArcelorMittal steel mill at the Point Lisas Industrial Estate in Trinidad and Tobago produces steel billets, direct-reduced iron pellets, and steel wire rods, all examples of iron and steel products. "Iron and steel" is treated as a single commodity, separate from iron ore, iron and steel scrap, or iron and steel slag.	No
COUNTRY	Country	Text	Country name	Country name	Yes

Table 8. Description of user-defined attribute fields in the mines and mineral processing facilities feature class *MINFAC_LAC*.—Continued

[ID, identification; e.g., for example; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
YEAR	Year	Numeric	Year of data source material in Volume III of the Minerals Yearbook. Ninety-five percent of records are from 2014.	2013, 2014, or 2015	No
COMMTYPE	Mineral commodity type	Text	Mineral commodity type	Three mineral commodity types: fuel, industrial, and metal. Fuel examples: Coal Methanol Natural gas Petroleum Industrial examples: Cement Clays Phosphate Metal examples: Gold Silver Lead Zinc Copper	No
COMMODITY	Mineral commodity	Text	Mineral commodity	USGS mineral commodity names	Yes
MIN_PROD	Form of mineral commodity product	Text	Specific form of a mineral commodity produced at a given facility	Variable depending on mineral commodity. Examples include: Ore Ores and concentrates Concentrates Refined (e.g., metal) Refinery products Crude (e.g., petroleum) Note: when unknown or unspecified, this field may simply be a duplicate of the COMMODITY field.	Yes

Table 8. Description of user-defined attribute fields in the mines and mineral processing facilities feature class *MINFAC_LAC*.—Continued

[ID, identification; e.g., for example; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
ADM1	First-order administrative division	Text	First-order administrative divisions are the equivalents of States in Brazil, Mexico, and the United States	Codeset from National Geospatial-Intelligence Agency	No
LOCDESC	Location description	Text	The full description of the location as given in the chapter of Volume III of the Minerals Yearbook Included to show how many specific locations may share an annual capacity when capacities are given for multiple locations	Variable text	Yes
LOCNAME	Location name	Text	Condensed version of location description, limited to specific mine or mineral processing plant name, if available or applicable	Variable. May just be a general statement (e.g., “Buenos Aires plant”).	Yes
FACTYPE	Facility type	Text	Type of facility, corresponding to symbology on map	• B – Brine operation • M – Mine • M/P – Co-located mine and plant • P – Mineral processing plant (processor of concentrate or refinery / smelter; post-concentrator) • OG – Oil and gas field • OR – Oil and gas refinery and (or) petrochemical complex	Yes
OPERATOR	Operating company	Text	Operator information from source material in Volume III of the Minerals Yearbook	First given value in the combined “Operator and ownership” column of individual country chapters within Volume III of the Minerals Yearbook.	Yes
OWNER	Ownership	Text	Ownership information from in Volume III of the Minerals Yearbook	Second given values in the combined “Operator and ownership” column of individual country chapters within Volume III of the Minerals Yearbook.	No

Table 8. Description of user-defined attribute fields in the mines and mineral processing facilities feature class *MINFAC_LAC*.—Continued

[ID, identification; e.g., for example; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
ANNCAP	Annual production capacity	Numeric	As listed in source material in Volume III of the Minerals Yearbook	Capacities may repeat several times due to geographically distinct facilities having a combined annual capacity. Care should be taken when adding capacities for the same mineral commodity within a country (see below with the "COMBOCAP" field description). These data may not be comprehensive for a given country.	Yes
ECAP	Estimated annual capacity	Text	Estimated annual production capacity	Flagged "e" if estimated.	No
UNITS	Units of measure for annual production capacity	Text	Units of measure for annual production capacity	• mt – metric tons • tmt – thousand metric tons • kg – kilograms • NA – not available / not applicable • mcm – million cubic meters • tcmpd – thousand cubic meters per day • t42-gb – thousand 42-gallon barrels • t42-gbpd – thousand 42-gallon barrels per day • m42-gb – million 42-gallon barrels	Yes
COMBOCAP	Combined capacities	Text	Some entries from original source material have multiple locations that share one given annual capacity figure. To track individual locations and retain the capacity information, this field acts as a flag to users so that they will not assume that the given capacity is for that one particular location only and instead is shared across multiple locations under the same ownership.	"***#-#" notation with FACID numbers (FACID_NUM) listed. For example, an entry flagged in this field as "***5-8" would indicate that the given annual production capacity is a combined figure for data records with the FACID_NUM's of 5, 6, 7, and 8. These entries should all have the same ownership information, but commonly include geographically distinct facilities.	Yes

Table 8. Description of user-defined attribute fields in the mines and mineral processing facilities feature class *MINFAC_LAC*.—Continued

[ID, identification; e.g., for example; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
STATUS	Operating status	Text	Assumed active for a given year if not annotated in source material.	• A – active • C – closed / past producer • CM – care and maintenance • S – suspended • U – unknown • UC – under construction • UD – under development	Yes
LOCACC	Locational accuracy	Text	Accuracy of the given coordinates for the facility	• A – Approximate location • E – Exact location	Yes
DDLAT	Latitude in decimal degrees	Numeric	Latitude in decimal degrees	Variable	No
DDLONG	Longitude in decimal degrees	Numeric	Longitude in decimal degrees	Variable	No
SOURCEID	Source / reference ID	Text	Source index number	Internal USGS reference to georeferencing sources Sources for this data field refer to the references used to determine geographic location. The actual source material for the data record is Volume III of the Minerals Yearbook.	No
COMMENTS	Comments	Text	Comments and explanatory notes	If included in source material	No

the annotation group containing the labels. The facility type appears in the middle of the text string; for example, “MINFAC_BRINE_ANNO” is the label annotation group for the brine operations map layer in the PDF.

For this report, the six facility type categories are defined as follows:

1. **Brine operations**
    - Facilities extracting or processing brine-based mineral solutions in the liquid form.
2. **Mines**
    - Operations producing either metallic mineral ores or mineral concentrates (including concentration mills / beneficiation plants that are not also producing refined metals or downstream products), including from surface mines and underground mines. Also including quarries producing industrial minerals.
3. **Mineral processing plants**
    - For metallic minerals, operations that consume mineral concentrates for processing downstream refined metallic products; for industrial minerals, such as cement plants, operations that process raw material into a finished industrial product.
4. **Combined mine and processing plants**
    - Where indicated in Volume III of the Minerals Yearbook, these facilities are co-located mining and processing operations, often with any ore or mineral concentrates produced or milled onsite also being processed into further downstream products at the adjacent processing plant. Within the geodatabase, these values are derived from the “LOCDESC,” or location description field.
5. **Oil and gas fields**
    - Oil and natural gas fields. Some individual data records may refer to a specific oil and gas field with an individual annual capacity for that field, whereas other data records may refer to an aggregated annual capacity number for one company across several fields in a wide geographic area, commonly at the first-order administrative level division.
6. **Oil and gas refineries and (or) petrochemical complexes**
    - Oil and gas refineries and (or) petrochemical complexes that are processing crude oil or natural gas into downstream petrochemical products.

The mineral facility data feature class contains more than 1,300 total records relating to the extractive mineral industries of Latin America and the Caribbean. More than 1,100 unique facilities are contained within this data feature class. Of the 33 independent countries and 16 dependencies of foreign governments within the LAC region, the *MINFAC_LAC* data feature class contains information on the mining and mineral processing facilities of 27 independent countries[8] and two foreign dependencies [Aruba (the Netherlands) and French Guiana (France)]. Independent countries and foreign dependencies that are not included in this feature class are those islands of the Caribbean which do not support any mining or mineral-related activity, or for which no available data were found.

Table 9 shows the distribution of data records by country. The top four countries on the basis of number of total records—Chile, Bolivia, Brazil, and Peru—account for approximately 66 percent of the total number of records, and are among the region’s largest producers of mineral commodities. However, other countries may have locally important mines and mineral processing facilities, which significantly contribute to those countries’ overall economies. As described in table 8 for the “MULTI_COMM” and “MULTI_PROD” fields, there is not a one-to-one relationship between the number of data records and the number of facilities. Facilities can be listed multiple times owing to multiple commodities being produced onsite (such as different metallic elements contained within ore and concentrated into separate mineral commodity products at a mine) or because different product forms of the same mineral commodity are produced onsite (such as a variety of steel products all being produced at a mill, each with a different annual production capacity listed in the table). Caution should be exercised when summing or aggregating information on annual production capacities. Multiple geopgrahically disparate facilities may share a single capacity if that is the lowest level of data resolution that was found by the original researchers of the individual chapters of Volume III of the Minerals Yearbook. These facilities are flagged by the field “COMBOCAP,” which stands for combined capacity, and have the individual facility identification numbers included in the data point of the “COMBOCAP” field.

By commodity type, metals accounted for 668 total records, or 50 percent, followed by industrial minerals with 433, or 33 percent, and fuel minerals with 231, or 17 percent. Based on geographic research to determine the location of facilities, 1,195 records, or 90 percent, have exact locational accuracy, with the other 137 records, or 10 percent, having approximate locations. Active facilities account for 1,149 records, or 86 percent, for the given calendar year of the source material. Twenty-two records, or 2 percent, were suspended, while all other operational statuses (under construction, under development, on care-and-maintenance, unknown, or closed) account for the remaining 12 percent of the total record count.

[8] The independent countries are Argentina, The Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, and Venezuela. All of these countries except Cuba are borrowing members of the Inter-American Development Bank.

Table 9. Total count of mineral facility data records in the *MINFAC_LAC* data feature class, by country.

[Percent totals are rounded to no more than two significant figures; may not add to totals shown]

Country	Total number of records per country	Percent of total for record count
Argentina	77	6
Aruba	1	0
Bahamas, The	1	0
Barbados	1	0
Belize	2	0
Bolivia	132	10
Brazil	241	18
Chile	372	28
Colombia	45	3
Costa Rica	8	1
Cuba	28	2
Dominican Republic	7	1
Ecuador	21	2
El Salvador	6	0
French Guiana	3	0
Guatemala	29	2
Guyana	4	0
Honduras	6	0
Jamaica	10	1
Mexico	79	6
Nicaragua	7	1
Panama	1	0
Paraguay	5	0
Peru	133	10
Suriname	15	1
Trinidad And Tobago	39	3
Uruguay	7	1
Venezuela	52	4
Total	**1,332**	

The top 20 mineral commodities by total number of records within this dataset all have at least 12 records each across all countries and represent 1,073 total data records, or 81 percent of the entire dataset. These commodities, in descending order of total record count, are: cement (176), petroleum (149), gold (131), iron and steel (119), copper (103), silver (75), natural gas (51), zinc (39), lead (37), calcium carbonate (27), coal (23), antimony (20), molybdenum (19), silica (19), bauxite (18), nickel (16), gypsum (14), nitrates (13), boron (12), and iodine (12). Note that these are among the region's best-known produced mineral commodities; however, it is also important to note that this is not a count of unique facilities but rather is a count of total data records. Some of these records may indicate double or multiple counting across facilities, as some mines produce multiple metal ores and concentrates from polymetallic deposits, and some mineral processing plants produce multiple different metals and or multiple single-metal products.

Oil and gas field center points—*OG_CENTER* feature class

More than 2,800 oil and gas field center points were derived from two maps showing the regional geology, oil and gas fields, and geological provinces of South America and the Caribbean, and were merged to create the *OG_CENTER* feature class. The original sources of the oil and gas field data were from the 1997 (South America) and 2002 (Caribbean, Central America, and Mexico) Petroconsultants International Data Corp. petroleum database, as published in USGS Open-File Reports 97–470–D and 97–470–K, respectively (Schenk and others, 1999; French and Schenk, 2004). These data do not contain attribute information on production or installed production capacity, which are included in the data from Volume III of the Minerals Yearbook in the *MINFAC_LAC* feature class. Therefore, this feature class represents a greater number of individual field points—which are included to show the overall areal extent of major oil and gas fields within the region—than are included in Volume III. The records shown in Volume III represent those fields for which country specialists had access to specific capacity data, either for individual fields or aggregated across an entire company or country.

Mineral exploration and development sites and other mineral resources—*B_MIN_EXPLORE* feature dataset

The feature dataset *B_MIN_EXPLORE* contains vector point data on mineral exploration sites (*EXPLORE_LAC* feature class) and vector polygon data on geologic tracts assessed for having the greatest porphyry copper mineral potential. Table 10 shows the individual feature classes within this feature dataset.

Table 10. Data feature classes within the *B_MIN_EXPLORE* feature dataset of the file geodatabase *LAC_Indust_Infra.gdb*.

Feature class name	Feature class name in geospatial PDF map	Description
EXPLORE_LAC	Mineral exploration and development sites	Vector point data on mineral exploration sites within Latin America and the Caribbean.
COAL_AREAS	Coal resources	Areas of coal occurrence.
CU_PORPH_TRACTS	Undiscovered porphyry copper resources	Vector polygon data for tracts having the greatest porphyry copper mineral potential.

Mineral exploration and development sites—*EXPLORE_LAC* feature class

Selected mineral exploration sites are included as a dataset to provide a regional overview of major mineral exploration sites in exploration or developmental stages. NMIC analysts annually collect and analyze global exploration data and publish a report that reviews worldwide exploration trends. These annual reviews provide data on exploration budgets by region and mineral commodity, identify significant mineral discoveries, and discuss governmental programs or regulatory actions (Wilburn and Karl, 2016). The exploration data contained in *EXPLORE_LAC* feature class is data from NMIC annual reviews researched using publicly accessible sources to confirm current mineral commodities of interest, project type, location, operational status, primary name, and primary ownership. Financial information on the level of capital or foreign investment into an exploration site or project is not included in this report.

A master global list of mineral exploration sites (not included as part of this report owing to the presence of a significant amount of proprietary data from a subscription service), analyzed by the NMIC for calendar year 2015, totaled 1,930 mineral exploration sites worldwide, with Latin America and the Caribbean accounting for approximately 340, or 18 percent. This feature class accounts for an approximate "top 100" and includes only those sites for which the NMIC had been tracking their exploration activity via public information separate from any propeietary sources of information. About two-thirds of the LAC sites in the master list reflect global trends of exploration, in which half the exploration activity globally is the exploration for and the identification of gold and silver deposits, and this trend is true within this dataset as well. Exploration for base metals was the next largest category, accounting for nearly an additional 80 sites, or about 20 percent.

Among global regions Latin America, since 2005, has had the largest exploration budget in nominal U.S. dollars. In 2015, the value of the region's exploration budget was approximately $2.5 billion, representing 25 percent of the world's total. This total, while still greater than for any other region identified by the USGS, was significantly less than the all-time high of almost $5.3 billion in 2012. A significant portion, 46 percent, of all sites within Latin America and the Caribbean were early-stage discoveries, whereas exploration at producing sites (commonly for mine expansions) accounted for 31 percent (Wilburn and Karl, 2016).

Table 11 describes the user-defined data attribute fields in the feature class. The full mineral exploration site feature class, as well as metadata explaining all attribute field values, codes, and abbreviations, is available as a USGS data release (Baker and Wilburn, 2016) through the USGS ScienceBase data release page, available at https://doi.org/10.5066/F7GQ6VWG.

The project type field "PROJTYPE" indicates the stage of exploration or development activity at a site. Different companies may report terms with different meanings but for the purposes of this report, these terms are defined in table 12 and are shown in temporal rather than alphabetical order.

Table 13 shows summary statistics on the total number of exploration projects by country and project type included in the exploration dataset for this report. The listed mineral commodity is the major exploration target for a particular site. Exploration and development work is extremely site-specific and is controlled by a range of geologic, economic, environmental, and social factors. Frequently, especially for metallic mineral commodities, there are additional metallic targets owing to the geology of any given ore deposit. However, depending on the stage of exploration, not all targeted minerals known to occur at a site will be present in sufficient quantities for economic feasibility for potential extraction. Often projects may be more narrowly developed in later stages to a specific mineral commodity or a subset of known mineral resources. Conversely, even if a mineral resource occurs in sufficient quantities at a particular site, the feasibility of development may be limited owing to economic factors (such as a price crash on major international exchanges, resulting in decreased funding potential from investors), environmental or social concerns (local, intra-, and international opposition), or physical inaccessibility (distance from major transportation networks).

Table 11. Description of user-defined attribute fields in the mineral exploration and development sites feature class *EXPLORE_LAC*.

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
ROWID	Row ID	Numeric (integer)	Unique ID number for each row	Sequential order, ascending	No
GENC_CC	GENC country code	Text	GENC two-digit country code	Unique to each country	No
FACID_NUM	Facility ID number	Numeric (integer)	Unique ID number per facility per country	Sequential order, ascending; restarts for each country	No
FACID	Facility ID	Alphanumeric	GENC_CC combined with FACID_NUM. Used as labels on map.	Sequential order, ascending	Yes
COUNTRY	Country	Text	Country name	Country name	Yes
ADM1	First-order administrative division	Text	First-order administrative divisions are the equivalents of States in Brazil, Mexico, and the United States	Codeset from National Geospatial-Intelligence Agency	No
YEAR	Year	Numeric	Year of data from source material	2013, 2014, or 2015	No
PROJTYPE	Project type	Text	Exploration or development project type	<u>Examples</u>: D – approved for or under development E – active exploration work ongoing F – feasibility work ongoing or completed P – exploration at a producing mine or mine expansion underway	Yes
PROJNAME	Project name	Text	Exploration or development project or site name	Variable text	Yes
COMM	Mineral commodities	Text	Known mineral commodities of interest at a project or site	USGS mineral commodity names. There may be more than one mineral commodity of interest known to occur at a project and several could be considered economically viable targets for exploration or production.	Yes
NUM_COMM	Number of mineral commodities	Numeric (integer)	Number of known mineral commodities of interest at a site	Variable	No
OPERATOR	Operating company	Text	Operating company information as from source material	Operating company information as from source material	No
OWNER	Ownership	Text	Ownership information as from source material	Ownership information as from source material	No

Table 11. Description of user-defined attribute fields in the mineral exploration and development sites feature class *EXPLORE_LAC*.—Continued

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
LOCACC	Locational accuracy	Text	Accuracy of the given coordinates for the facility	• A – Approximate location • E – Exact location	No
DDLAT	Latitude in decimal degrees	Numeric	Latitude in decimal degrees	Variable	No
DDLONG	Longitude in decimal degrees	Numeric	Longitude in decimal degrees	Variable	No
SOURCEID	Source / reference ID	Text	Source index number	Internal reference to sources for USGS	No

Table 12. Description of user-defined attribute field "PROJTYPE" in the mineral exploration and development sites feature class *EXPLORE_LAC*.

PROJTYPE abbreviation	Field alias	Explanation
E	Active exploration work ongoing	May include a range of exploration work, including drilling for assay samples or mineral deposit delineation work to determine spatial and geologic characteristics of the deposit.
F	Feasibility work ongoing or completed	Mineral deposit discovered and studies undertaken to determine economic viability.
D	Approved for or under development	Post-feasibility and permitted to develop a property having an economically viable mineral deposit toward becoming a producing mine.
P	Exploration at a producing mine or mine expansion underway	Note: any mine expansion may include the other stages of exploration or development work, depending on the stage of mine expansion.

Table 13. Total counts of selected mineral exploration and development sites in Latin America and the Caribbean, by country and project type, 2013–15, from the *EXPLORE_LAC* feature class.

[D, approved for or under development; E, active exploration work ongoing; F, feasibility work ongoing or completed; P, exploration at a producing mine or mine expansion underway]

Country and primary mineral commodities at an exploration site	Project type				Grand total
	D	E	F	P	
Argentina					
Copper (also with gold, molybdenum, silver)		1	4		5
Gold (also with copper, silver, lead, and zinc)		1		2	3
Lithium		3	1		4
Natural gas, shale oil		1			1
Silver (also with lead and zinc)		1	1		2
Triuranium octoxide (U_3O_8)		1	1		2
Argentina subtotal		8	7	2	17
Bolivia					
Lithium	1				1
Silver, tin, zinc				1	1
Bolivia subtotal	1			1	2
Brazil					
Bauxite			1		1
Copper (gold and silver)	1	1	1		3
Gold		2		3	5
Iron ore	3		5		8
Phosphate			4		4
Sulfate of potash		1			1
Brazil subtotal	4	4	11	3	22
Chile					
Copper	1	6	10	2	19
Gold, silver		1		1	2
Iron ore	1		2	1	4
Silver, gold, antimony				1	1
Chile subtotal	2	7	12	5	26
Colombia					
Gold (also with silver)		2		1	3
Colombia subtotal		2		1	3
Ecuador					
Copper (also with gold and silver)			1		1
Ecuador subtotal			1		1
French Guiana					
Gold			1		1
French Guiana subtotal			1		1
Guyana					
Bauxite			1		1
Guyana subtotal			1		1

Table 13. Total counts of selected mineral exploration and development sites in Latin America and the Caribbean, by country and project type, 2013–15, from the *EXPLORE_LAC* feature class.—Continued

[D, approved for or under development; E, active exploration work ongoing; F, feasibility work ongoing or completed; P, exploration at a producing mine or mine expansion underway]

Country and primary mineral commodities at an exploration site	Project type				Grand total
	D	E	F	P	
Jamaica					
Copper, gold			1		1
Jamaica subtotal			1		1
Mexico					
Copper (also with gold and silver)		4	7		11
Gold (also with silver)	1	1		5	7
Lithium			1		1
Silver (also with copper, gold, lead, and zinc)		3		4	7
Mexico subtotal	1	8	8	9	26
Peru					
Copper (also with gold and silver)	1	2	6		9
Heavy mineral sands		1			1
Iron ore			1		1
Phosphate			2		2
Silver, gold				1	1
Peru subtotal	1	3	9	1	14
Suriname					
Bauxite			1		1
Gold				1	1
Suriname subtotal			1	1	2
Grand total	**9**	**32**	**52**	**23**	**116**

Coal occurrence areas—*COAL_AREAS* feature class

Coal occurrence areas (also known as coal-bearing areas) are included for general spatial reference as the data feature class *COAL_AREAS*. The USGS published a compilation of coal data for the Western Hemisphere in 2008 in anticipation of increases in coal consumption and international trade of coal based on projections from the U.S. Energy Information Administration in 2007 (Tewalt and others, 2008). Coal resources were found to be prominent in about 125 areas of 30 countries of the Western Hemisphere. However, the data in this feature class are not suitable for coal resource calculations. The areas included are for general reference, not adjusted for geologic structure, and they do not include coal at depth but instead represent generalized analysis of surficial geology (Tewalt and others, 2008). For example, a large area of Tertiary lignite occurrences exists in northern Peru in the Maranon-Montana Basin of Loreto Department. The extent of this area varies based on source (for example, this region is shown smaller by Weaver and Good [1994]), but the representations in this feature class represent work from across many publications to show total potential for coal occurrences or areas of known occurrences. These areas delineate the known potential for coal occurrences based on surficial geology and do not indicate equal distribution of coal throughout the entire area. Table 14 shows the distribution by rank of the coal resource (type of coal) and table 15 shows the user-defined attribute fields included in the *COAL_AREAS* feature class. The term “mixed ranks” refers to those coal ranks that in the original data are coal-bearing areas that include a mixture of coal ranks in a range, such as “bituminous to anthracite,” or “bituminous to semi-anthracite.” Some data points within the original data are also marked with a question mark to denote uncertain rank; these values are included in the mixed values total. A few areas had coal rank as “not reported” and are not included in any specific rank shown.

Table 14. Number of coal occurrence areas in Latin America and the Caribbean, by coal rank and by country, from the *COAL_AREAS* feature class.

[Data from Tewalt and others, 2008. Note: in the feature class data table within the geodatabase, users may see values marked with a question mark. These values are of uncertain rank and are included in the mixed value totals]

Country or countries	Coal rank (also known as coal type)						Total number of coal occurrence areas
	Anthracite	Bituminous	Subbituminous	Lignite	Mixed ranks	Not reported	
Argentina		5	7				12
Argentina-Chile	1	1	3				5
Bolivia				1			1
Brazil		5			1		6
Brazil-French Guiana					1		1
Chile		2	4				6
Colombia	1	14	5	1	3		24
Colombia-Venezuela			3				3
Costa Rica			1	3			4
Costa Rica-Panama			1				1
Cuba				1			1
Dominican Republic				1			1
Ecuador			2	1	2		5
Ecuador-Peru				1			1
Guatemala				9	3	1	13
Haiti				1			1
Honduras			4	1	2	1	8
Jamaica				1			1
Mexico		7		1	5		13
Nicaragua				2			2
Panama				5			5
Paraguay					1		1
Peru		2	3		1		6
Peru-Ecuador				1			1
Uruguay-Brazil			1				1
Venezuela					2		2
Total	**2**	**36**	**34**	**30**	**21**	**2**	**125**

Table 15. Description of user-defined attribute fields in the coal occurrence areas feature class *COAL_AREAS*.

[From Tewalt and others, 2008. NA, not applicable or not available]

Field alias	Data field description	Data field example values
FID	Feature identification number	NA
Age	Geologic age of the coal represented by the polygon	Cenozoic Quaternary Tertiary Pliocene Miocene Oligocene Eocene Paleocene Mesozoic Cretaceous Jurassic Triassic Paleozoic Permian Carboniferous Pennsylvanian Mississippian Devonian
Source	Source material or original publication of the data	NA
Rank	Apparent rank calculated from proximate analysis data	Lignite Subbituminous Bituminous Anthracite
Country	Country or countries in which a coal-bearing area occurs	Argentina Bolivia Brazil Chile Colombia Costa Rica Cuba Dominican Republic Ecuador Guatemala Haiti Honduras Jamaica Mexico Nicaragua Panama Paraguay Peru Uruguay Venezuela
Continent	Continent or continents in which a coal-bearing area occurs	North America South America
Min_age	Minimum age of the coal represented by the polygon	Same range of values as Age data field
Max_age	Maximum age of the coal represented by the polygon	Same range of values as Age data field

Undiscovered porphyry copper / polymetallic[9] resources—*CU_PORPH_TRACTS* feature class

As part of a global copper mineral resource assessment, the USGS Mineral Resources Program (MRP) analyzed two deposit types which, when combined, account for approximately 80 percent of the world's copper supply; porphyry copper deposits alone account for about 60 percent and sediment-hosted stratabound copper deposits account for the other 20 percent. These two deposit types produce approximately 12 million metric tons of copper per year (Johnson and others, 2014). In 2008 and 2010, the results of a series of mineral resource assessments for porphyry copper deposits conducted in partnership with counterpart scientific agencies in countries across Latin America and the Caribbean region were published (Cunningham and others, 2008; Gray and others, 2014; Hammarstrom and others, 2010).

A total of 43 geographic areas were outlined by the MRP as permissive tracts that may contain undiscovered porphyry copper deposits and prospects within 1 kilometer (km) of the surface: 26 tracts for South America in the Andes Mountains; 12 tracts for Mexico, primarily in the Sierra Madre Occidental stretching from the U.S.-Mexico border to the south-central part of Mexico; and 5 tracts along the mountainous cordillera of Central America and among the islands of the Caribbean. Tracts were delineated primarily on the basis of tectonic setting, occurrences of types of igneous rocks known to host porphyry copper deposits, exploration history, and distribution of known porphyry copper deposits and prospects. Probabilistic estimates of numbers of undiscovered deposits in each tract were combined with appropriate grade and tonnage models to derive probabilistic estimates of the amounts of copper, gold, molybdenum, and silver that could be contained within any undiscovered deposits within a tract.

Table 16 shows characteristics and model estimates for several of the tracts having the greatest estimated mean metal content for each of the three sub-regions—these tracts and data are those shown in the *CU_PORPH_TRACTS* feature class. Other tracts that were assessed, but which contain lower estimates for mean metal content, are included in the feature class shown on the map with gray shading. Attribute data for these other tracts can be accessed through the map document or geodatabase for reference.

The tract having the greatest total expected mean metal content in the entire region is the Chile Eocene-Oligocene Chuquicamata tract along the Argentina-Chile border in the Andes of South America, with an estimated 210 million metric tons (Mt) of copper content, 6.3 Mt of molybdenum content, 1,300 metric tons (t) of gold content, and 70,000 t of silver content contained in 27 billion metric tons (Gt) of host rock. Among the Caribbean and Central American tracts, the Cocos tract stretching from southern Mexico into Panama but mostly located in Honduras and Nicaragua contains the greatest expected mean metal content, with an expected 53 Mt of copper, 1.4 Mt of molybdenum, 1,300 t of gold, and 18,000 t of silver contained in 11 Gt of host rock. The leading Mexican tract is the Sierra Madre Occidental (West) tract, stretching from the U.S.-Mexico border to the Mexican State of Sinaloa, with an estimated 48 Mt of copper, 1.3 Mt of molybdenum, 1,200 t of gold, and 16,000 t of silver contained in 9.9 Gt of host rock.

Tracts having the greatest expected mean metal content are not necessarily those with the greatest number of known or undiscovered deposits. For South America, the Peru-Ecuador middle-late Miocene La Granja tract has the greatest number of undiscovered deposits (15) that could occur based on the model, yet the tract overall ranks third for expected mean copper content. However, for Mexico and the Caribbean and Central America, the Sierra Madre Occidental (West) and Cocos tracts (those with the highest expected copper content) do contain the greatest number of undiscovered deposits, 13 and 14, respectively. The permissive tracts listed in table 16 range in area from about 3,000 to 200,000 square kilometers (km^2).

[9]In this context, the term "polymetallic" is used to denote mineral resources covering several discrete potential recoverable metals extractable from a mineral resource.

Table 16. Undiscovered porphyry copper tracts assessed by the U.S. Geological Survey, containing the greatest estimated mean undiscovered metal content in the Caribbean and Central America, Mexico, and South America, 2008–10, from the *CU_PORPH_TRACTS* feature class.

[Data from Cunningham and others, 2008; Hammarstrom and others, 2010; and Gray and others, 2014. Tracts identified contain the greatest total metallic resource estimates and the greatest number of total estimated undiscovered and known deposits. ENUD, estimated mean number of undiscovered deposits; ID, identification. Total number of deposits is rounded to two significant digits]

Tract ID	Coded ID	Tract name	Country / countries	Assessment country or region	Deposits			Estimated mean undiscovered metal content and total host-rock tonnage (thousand metric tons)				
					ENUD	Number of known deposits	Total number of deposits	Copper	Molyb-denum	Gold	Silver	Total host-rock tonnage
MX-L2	003pCu3007	Sierra Madre Occidental (West)	Mexico	Mexico	13	15	28	48,000	1,300	1.2	16	9,900,000
MX-T3	003pCu3011	Southwest Mexico	Mexico	Mexico	9.6	3	13	37,000	1,000	0.940	12	7,500,000
MX-L3	003pCu3008	Laramide Central Plateau	Mexico	Mexico	5.5	0	6	20,000	560	0.51	6.5	4,100,000
MX-L1	003pCu3006	Western Mexican Basin and Range	Mexico	Mexico	4.2	1	5	16,000	460	0.400	5.6	3,300,000
MX-T2	003pCu3009	Tertiary Central Plateau	Mexico	Mexico	2.5	0	3	9,600	260	0.250	3.1	1,900,000
MX-T1	003pCu3010	Eastern Alkaline Province	Mexico	Mexico	2.2	0	2	6,700	39	0.49	2.2	1,300,000
SA10abPC	005pCu010b	Chile Eocene-Oligocene Chuquicamata	Argentina-Chile	South America	6	10	16	210,000	6,300	1.3	70	27,000,000
SA14bPC	005pCu014b	Chile Miocene-Pliocene El Teniente	Chile	South America	1.9	2	3.9	69,000	2,000	0.44	24	8,900,000
SA06PC	005pCu006	Peru-Ecuador middle-late Miocene La Granja	Peru-Ecuador	South America	15	12	27	49,000	1,200	1.2	16	9,700,000
SA08PC	005pCu008	Chile-Peru Paleocene-Eocene Toquepala	Chile-Peru	South America	12	12	24	43,000	1,100	1	14	8,400,000
SA13bPC	005pCu013b	Argentina-Chile Miocene-Pliocene Los Pelambres	Argentina-Chile	South America	6.4	2	8.4	22,000	560	0.52	7	4,300,000
CA_CARIB_T2	003pCu4004	Cocos	Central America	Central America and the Caribbean	14	2	16	53,000	1,400	1.3	18	11,000,000

Table 16. Undiscovered porphyry copper tracts assessed by the U.S. Geological Survey, containing the greatest estimated mean undiscovered metal content in the Caribbean and Central America, Mexico, and South America, 2008–10, from the *CU_PORPH_TRACTS* feature class.—Continued

[Data from Cunningham and others, 2008; Hammarstrom and others, 2010; and Gray and others, 2014. Tracts identified contain the greatest total metallic resource estimates and the greatest number of total estimated undiscovered and known deposits. ENUD, estimated mean number of undiscovered deposits; ID, identification. Total number of deposits is rounded to two significant digits]

Tract ID	Coded ID	Tract name	Country / countries	Assessment country or region	Deposits			Estimated mean undiscovered metal content and total host-rock tonnage (thousand metric tons)				
					ENUD	Number of known deposits	Total number of deposits	Copper	Molyb-denum	Gold	Silver	Total host-rock tonnage
CA_CARIB_KT1	003pCu4001	Santiago	Caribbean islands, including Cuba, Hispaniola, Jamaica, Puerto Rico	Central America and the Caribbean	12	4	16	36,000	210	2.7	12	7,400,000
CA_CARIB_KT2	003pCu4003	Chortis	Mostly Honduras	Central America and the Caribbean	6.1	0	6.1	23,000	640	0.57	7.3	4,600,000
CA_CARIB_T1	003pCu4002	Darién	Panama	Central America and the Caribbean	3.5	1	4.5	14,000	400	0.34	4.4	2,900,000
CA_CARIB_T3	003pCu4005	Lesser Antilles	Lesser Antilles	Central America and the Caribbean	1.1	0	1.1	3,300	19	0.24	1.1	680,000

Energy infrastructure—*C_ENERGY_INFRA* feature dataset

The feature dataset *C_ENERGY_INFRA* contains vector point and polyline data feature classes covering the infrastructure relating to the production of electric energy (electric power generating plants and transmission lines), as well as associated infrastructure for the petroleum industries, including pipelines and operational liquefied natural gas terminals. Table 17 shows the individual feature classes within this feature dataset.

Electric power generating facilities—*POWER_LAC* feature class

Major electric power generating facilities in the LAC region, also known as powerplants, were researched to present the overall scale and distribution of electric generating power. Extractive industries, including mining and oil and gas extraction, are dependent on locally available and reliable sources of electric energy in large quantities to power their operations. Some countries—such as those in the Southern Cone (Argentina, Brazil, Chile, and Uruguay)—have well-developed, internationally connected electric grid systems, capable of generating and distributing electric power for major metropolitan areas and heavy industries. Other countries, notably those in the Caribbean, have smaller grid systems reliant on smaller-capacity generating plants, with industries commonly generating their own electric power onsite (McIntyre and others, 2016). Using publicly available geospatial and non-geospatial sources, a dataset with over 500 data points was created based on information available from the governments of foreign countries regarding powerplants, their locations, their installed capacities, and energy sources. Data were collected from a range of national authorities, including:

- Argentina—Ministerio de Energía y Minería
- Bolivia—Autoridad de Fiscalización y Control de Electricidad
- Brazil—Agência Nacional de Energia Eléctrica
- Chile—Ministerio de Energía
- Ecuador—Corporación Eléctrica del Ecuador
- Mexico—Instituto Nacional de Estadística y Geografíca
- Peru—Ministerio de Energía y Minas

In some cases, such as data for Brazil and Chile, the criterion for inclusion in this dataset was facilities having the greatest installed electric power generating capacities: for Brazil, greater than or equal to 400 megawatts (MW), and for Chile, greater than or equal to 100 MW. For other countries, based on available data sources, the criterion was set lower—for example, Peruvian data are those facilities having an installed electric power generating capacity greater than or equal to 30 MW. However, for smaller countries, including those in Central America, that do not contain facilities as large as in other countries, facilities were included based on available research. Some data gaps may be present depending on the country. Table 18 highlights the main feature attributes and data fields within the electric power generating facility feature class.

In 2010, the World Bank reported that six countries within the LAC region accounted for 84 percent of the region's total electric power generating capacity in 2010: Brazil (36 percent), Mexico (21 percent), Argentina (9 percent), Venezuela (9 percent), Colombia (5 percent), and Chile (4 percent) (Yepez-García and others, 2010). In 2010, hydroelectric dams represented 65 percent of all electric power capacity in the region, with a total installed capacity nearing 153 gigawatts (Wheeler, 2012). In 2013, the Inter-American Development Bank stated that, for its member states, installed power capacity was relatively unchanged from 2010: Brazil, 37 percent; Mexico, 19 percent; and the Southern Cone [Argentina, Chile, Paraguay, and Uruguay], 18 percent (Flavin and others, 2014).

Paraguay is a significant producer of hydroelectricity owing to the Itaipu Binacional dam that straddles the Brazil-Paraguay border—the largest electric power generating facility in the LAC region and the second largest power producing facility in the world, with a total installed capacity of 14 gigawatts. Most of Paraguay's production is immediately sold back to Brazil (Yepez-García and others, 2010). For this reason,

Table 17. Data feature classes within the *C_ENERGY_INFRA* feature dataset of the file geodatabase *LAC_Indust_Infra.gdb*.

Feature class name	Description
POWER_LAC	Vector point data. Electric power generating facilities within the region, including energy source (geothermal, hydroelectric, nuclear, solar, thermal, and wind). Thermal energy sources include coal, gas, and oil-fired powerplants.
OG_CONC_AREAS	Oil and gas concession leasing areas
PETRO_PROV	USGS petroleum provinces
TRANSMISSION	Vector polyline data. Electric power transmission lines. No attribute data; provided only for visual spatial reference.
LNG	Vector point data. Liquefied natural gas terminals, including facility type (regasification or liquefaction).
PIPELINES	Vector polyline data. Oil and natural gas pipelines. No attribute data; provided only for visual spatial reference. Not broken into specific product pipelines.

Table 18. Description of user-defined attribute fields in the electric power generating facilities data feature class *POWER_LAC.*

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
ROWID	Row ID	Numeric (integer)	Unique ID number for each row	Sequential order, ascending	No
GENC_CC	GENC country code	Text	GENC two-digit country code	Unique to each country	No
FACID_NUM	Facility ID number	Numeric (integer)	Unique ID number per facility per country	Sequential order, ascending; restarts for each country	No
FACID	Facility ID	Alphanumeric	GENC_CC combined with FACID_NUM Used as labels on map	Sequential order, ascending	Yes
FID_ORIG_DATA	Feature identifier from original data source	Numeric (integer)	Unique facility identifier from original source publications	Variable numeric; derived from source publications	Yes
COUNTRY	Country	Text	Country name	Country name	Yes
ADM1	First-order administrative division	Text	First-order administrative divisions are the equivalents of States in Brazil, Mexico, and the United States	Codeset from National Geospatial-Intelligence Agency	No
PLANTNAME	Electric power generating facility name	Text	Facility name	Variable text	Yes
CITY	City	Text	Location of electric power generating facility	Variable text	No
ENERGY_TYPE	Energy source category	Text	Primary energy source for electric power generation	• Geothermal • Hydroelectric • Nuclear • Solar • Thermal • Wind	Yes
OPERATOR	Facility operator	Text	Operator of the facility, if known	Variable text	Yes
OWNER	Facility owner	Text	Owner of the facility, if known	Variable text	Yes
CAPACITY_MW	Installed electric production capacity in megawatts	Numeric (integer)	Installed electric production capacity in megawatts	Installed electric production capacity in megawatts	Yes

Table 18. Description of user-defined attribute fields in the electric power generating facilities data feature class *POWER_LAC*.—Continued

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
LOCACC	Locational accuracy	Text	Accuracy of the given coordinates for the facility	• A – Approximate location • E – Exact location	No
DDLAT	Latitude in decimal degrees	Numeric	Latitude in decimal degrees	Variable	No
DDLONG	Longitude in decimal degrees	Numeric	Longitude in decimal degrees	Variable	No
SOURCEID	Source / reference ID	Text	Source index number	Source identification number that corresponds to a source entry in the geodatabase metadata	No

Itaipu is included in the dataset as a Brazilian facility, although it is shared by the two countries. This situation is similar for the Acaray (listed as a primarily Brazilian facility in this dataset) and Yacyreta Binacional (Argentina) plants, which also occur on waterways sharing the border of Paraguay. In 2010, Brazil accounted for 74 percent of all hydroelectric power generated in the LAC region (Wheeler, 2012), and as of 2015, had 92 gigawatts of installed hydroelectric power capacity, accounting for 65 percent of the country's overall energy needs (International Hydropower Association, 2016).

Other energy sources used to produce electricity for the region account for a smaller share of total installed capacity. Six nuclear reactors were operational in the region as of 2016. They are, by country: (1) Atucha I and II and Embalse in Argentina; (2) Angra I and II in Brazil, both co-located at Praia de Itaorna, Rio de Janeiro State; and (3) Laguna Verde in Mexico. Angra III in Brazil is under construction and has not yet been brought online. Powerplants using fossil fuels are categorized in this report under the "thermal" category. The only country with significant coal-fired plant development plans is Colombia, which possesses the region's largest coal reserves and remains the region's largest coal exporter (Yepez-García and others, 2010). Petroleum-fueled power generating plants, which use fuel oil or diesel, account for the majority of smaller capacity facilities, concentrated mostly in island countries in the Caribbean, as well as in French Guiana, Guyana, and Suriname. In 2005, 75 percent of Caribbean countries relied on petroleum-burning power facilities to generate electric power, in contrast to the regional total of 14 percent (Yepez-García, 2010). In 2012, almost a decade later, 41 percent of the Caribbean's installed power capacity was reliant on fuel oil and diesel as a primary energy source, with 47 percent reliant on natural gas (Inter-American Development Bank, 2014).

Large disparities exist relative to electricity access within the countries of Latin America and the Caribbean; access is almost entirely dependent on proximity to either larger metropolitan areas or to large hydroelectric dams. In 2008, Peru had the largest disparity in electrification rates between rural and urban areas: 28 percent versus 96 percent. In addition to Peru, Bolivia, Haiti, Honduras, and Nicaragua each had rural electrification rates under 50 percent (Yepez-García and others, 2010). Some studies analyzing the power distribution in the region focus on electricity accessibility rates by demographics and population density, however, this does not reflect upon the distribution of power for mining. Mines, especially those in wilderness areas in the Andes, tend to rely on generating their own electric power through relatively smaller-scale diesel generators in addition to connecting to larger transmission grids. Several mines in Chile have been transitioning to renewable energy sources in order to lower their reliance on diesel fuel, including using small-scale solar to partially operate solvent extraction-electrowinning plants (Dixon and Nakagawa, 2016, p. 7).

The lack of diversification among energy types within a country's individual power system can pose problems with consistent generation and distribution of electricity, leading to electric supply shortages intra- and internationally. The heavy reliance on hydroelectricity has been impacted by large-scale regional weather events. The 2016 El Niño in the Pacific Ocean altered rainfall patterns and caused a drought that shut down Venezuela's Guri Dam for an extended period. The dam had accounted for 60 percent of the country's power production and the result was widespread power outages that affected major metropolitan areas and industrial facilities (Cawthorne, 2016). Brazil is also very reliant on hydroelectricity and as of 2016 had been experiencing a mutli-year drought that has negatively impacted States with major population centers and industrial activity, including Bahia, Minas Gerais, Pernambuco, Rio de Janeiro, and São Paulo (International Hydropower Association, 2016).

Oil and gas concession leasing areas—*OG_CONC_AREAS* feature class

Where data sources were available and reproduceable, oil and gas concession leasing areas were compiled and digitized to create the *OG_CONC_AREAS* feature class. These areas are included in the geospatial PDF map as a visual spatial reference and do not contain attribute information. Few countries publish comprehensive leasing attribute information in a digital format including details on current lease-holders of concession areas; however some countries, such as Peru, make their geospatial concession footprint data available online (PeruPetro S.A., 2016). Data were obtained from the following foreign government ministries and agencies, where available and applicable:

- Argentina—Ministerio de Energía y Minería, 2017, including both:
    - Producción Hidrocarburos Concesiones de Explotación
    - Producción Hidrocarburos Lotes de Explotación
- Belize—Ministry of Energy, Science and Technology, and Public Utilities, 2015
- Brazil— Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
- Colombia—Unidad de Planeacion Minero Energetica and Agencia Nacional de Hidrocarburos, 2015
- Dominican Republic—Ministerio de Energía y Minas, 2015
- Guatemala—Ministerio de Energía y Minas, Dirección General de Hidrocarburos, 2007
- Mexico—Comisión Nacional de Hidrocarburos, 2017
- Paraguay—Viceministerio de Minas y Energia, 2016
- Peru—PeruPetro S.A., 2016

Over 5,000 delineated areas (also referred to as blocks) are included and these vary greatly in spatial scale and resolution. Some delineated areas in mountains of Colombia or along the eastern central coast of Mexico may be no larger than 50 km^2; other individual blocks may be as large as 30,000 km^2 or more. Some countries may only have data on offshore areas, with no available data on inland oil and gas concession leasing areas. Although most countries have delineated blocks for leasing purposes, not all blocks are leased or explored. For example, exploration of Cuba's offshore blocks has been limited to a few nearshore sites off the northern coast, with limited to no exploration pursued in areas held to the west of the country in the Gulf of Mexico (Wacaster and others, 2015). For the entire region, comparing the *OG_CENTER* data feature class—showing the center points of producing oil and gas fields—against *OG_CONC_AREAS* shows that not all delineated areas open for leasing have actually had discovery or production.

Offshore concession leasing areas are usually within a country's exlcusive economic zone (EEZ), or less than 200 nautical miles offshore. Some areas within this feature class may appear farther than this distance, as the EEZ may have been calculated based on a country's island possessions that are not prominently visible at the scale of the geospatial PDF map. A maritime dispute exists between Colombia and Nicaragua involving significantly overlapping offshore rights within both countries' EEZs, owing to the location of the Colombian department of the Archipelago of San Andrés, Providencia, y Santa Catalina. Such diplomatic disputes prevent further natural resource exploration or extraction (Kashi, 2013).

USGS petroleum provinces—*PETRO_PROV* feature class

In the late 1990s, in anticipation of conducting worldwide assessments of petroleum provinces using a consistent total petroleum systems approach, the World Energy Project of the USGS divided the world into 937 geologic provinces to support future assessments of undiscovered hydrocarbon resources (Klett and others, 1997). The *PETRO_PROV* feature class contains the petroleum provinces that are within this project's study area (including some shared between the United States and Mexico). Petroleum provinces contain common geologic attributes and may include a single dominant structural element, such as a basin or fold belt. Where applicable they follow natural geological boundaries. Within Latin America and the Caribbean, but excluding provinces in the Gulf of Mexico that are entirely within the territorial waters of the United States, there are 159 delineated petroleum provinces, of which 80 are represented on the map. These 80 are those in which oil and gas field-level data were available from the Information Handling Services (IHS) International Exploration and Production Database (IEPD)[10] (see following section, "Oil and gas cumulative production and rank, recoverable proven plus probable hydrocarbon resources, and undiscovered hydrocarbon resources from IHS IEPD and

[10]The IHS International Exploration and Production Database was accessed by USGS researchers when the company conducted business as IHS Global. In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit.

USGS—*D_IHS_USGS_OG_DATA* feature dataset" for further discussion).

These petroleum provinces vary greatly in areal extent and typically cross international boundaries. The largest province by areal extent included in this report, the Andean Province, stretches along the Pacific coast of South America from southern Ecuador to the extreme southern tip of Chile. This province surrounds several smaller distinct provinces, such as the Temuco and Altiplano Basins, which were separately identified owing to those regions' specific geologic features. Offshore basins are included, among them the well-known oil-producing provinces off the coast of Argentina, Brazil, and Uruguay: the Espírito Santo, Campos, Santos, Pelotas, and East Patagonia Basins.

Electric power transmission lines—*TRANSMISSION* feature class

Electric power transmission line data were obtained from geospatial directories or online catalogs of foreign countries or digitized from maps representing very broad outlines of the electric power distribution network to create the *TRANSMISSION* feature class. Transmission lines plotted on the map of this report are not necessarily to scale on-the-ground, nor do they contain any attribute information as to total kilowatt capacity or kilowatt-hours delivered; they are provided as a visual spatial reference to add to the understanding of the region's broader industrial infrastructure. The length of all electric power transmission lines represented in this report totals almost 250,000 km. An integrated regional grid, similar to that of North America, is not fully operating across the entire LAC region. In Central America, construction has begun to create interconnectors between Mexico and Colombia in order to unify the North American and northern South American grid systems (Flavin and others, 2014). Other parts of the region—such as the Caribbean and the Guyanas (French Guiana, Guyana, and Suriname)—are still reliant on fairly low-wattage power generation from oil- and diesel-burning facilities with little international infrastructure for power sharing.

Where applicable and available, data were obtained as geospatial formats or digitized from a variety of foreign governmental sources, including the following ministries and agencies:

- Argentina—Ministerio de Energía y Minería, 2017
- Bolivia—Autoridad de Fiscalización y Control de Electricidad, 2016
- Brazil—Agência Nacional de Energia Eléctrica, 2016
- Chile—Ministerio de Energía, 2017: Sistema de Transmisión Eléctrica (Linea de Transmisión SING, Linea de Transmisión SIC, Linea de Transmisión Aysen)
- Colombia—Unidad de Planeacion Minero Energetica and Ministerio de Minas y Energía
- Ecuador—Corporación Eléctrica del Ecuador, 2014
- Peru—Ministerio de Energía y Minas, 2011
- Venezuela—Corporación Eléctrica Nacional S.A. (CORPOLEC), 2017

Liquefied natural gas terminals—*LNG* feature class

Table 19 shows example attribute data of the *LNG* feature class from the 2016 global directory published by the International Gas Union; the file geodatabase data table contains additional attribute information, including nameplate capacity and latitude and longitude in decimal degrees. In 2014, the International Energy Agency estimated that the global trade of liquefied natural gas (LNG) would rise by 40 percent to 450 billion cubic meters by 2019, and, as part of this increase, that total LNG exports from the United States to the LAC region could climb to approximately 241 million cubic meters, or 8.5 billion cubic feet, a day by 2020 (Burma and Hong, 2014). In a report from 2015 with The Inter-American Dialogue, the Inter-American Development Bank projected that countries within the LAC region will benefit from any U.S. gas boom in the future, given rising gas demand in most countries and the conversion of oil-fired powerplants to burn cheaper and cleaner natural gas. Most countries within the region remain net importers of natural gas (Viscidi and others, 2015, p. 1). Trinidad and Tobago and Peru are the two leading net exporters of LNG, through the four Atlantic LNG terminals at Point Fortin, Trinidad, and the Peru LNG Camisea terminal, respectively (Viscidi and others, 2015, p. 7). These countries had the only operational liquefaction terminal complexes within the LAC region as of 2016; the only other operational liquefaction terminal in the Western Hemisphere was at Kenai, Alaska, U.S. (International Gas Union, 2016, p. 22). Trinidad and Tobago produced 39 percent of the LAC region's total LNG demand in 2014; the majority of Peruvian LNG was shipped to Mexico (Viscidi and others, 2015, p. 7). The 11 regasification terminals within the region convert LNG back into a gaseous state for transportation and consumption: Brazil and Mexico, each with three; Argentina and Chile, each with two; and one in the Dominican Republic.

Oil and gas pipelines—*PIPELINES* feature class

Oil and gas pipeline polyline data were obtained from foreign governmental ministries' or agencies' online geospatial infrastructure web portals or derived from existing maps and digitized to compile the *PIPELINES* feature class. No attribute information is present within this feature class and it is provided for visual spatial reference. Some information on product differentiation is present in original source material,

Table 19. Active liquefied natural gas terminals in Latin America and the Caribbean, 2016, from the *LNG* data feature class.

[Data derived from International Gas Union, 2016. km, kilometer; LNG, liquefied natural gas]

Country	Terminal type	Terminal name	Location description	Owner(s) and percent share of ownership, where known
Argentina	Regasification	Bahía Blanca GasPort	Bahía Blanca	YPF, 100
Argentina	Regasification	GNL Escobar / Puerto Escobar	11 km north of Escobar	ENARSA, 100
Brazil	Regasification	Bahia / TRBA	Baía de Todos os Santos, Salvador, in the state of Bahia	Petrobras, 100
Brazil	Regasification	Guanabara LNG / Rio de Janeiro	Guanabara Bay, Rio de Janeiro	Petrobras, 100
Brazil	Regasification	Pecém	Pecém	Petrobras, 100
Chile	Regasification	Mejillones LNG	Bahía de Mejillones del Sur	GDF Suez, 63; CODELCO, 37
Chile	Regasification	Quintero LNG	Quintero	ENAGAS, 20.4; ENAP, 20; ENDESA, 20; Metrogas, 20; Oman Oil, 19.6
Dominican Republic	Regasification	AES Andrés	Outside of Santo Domingo	AES, 100
Mexico	Regasification	Altamira LNG	Altamira, Tamaulipas	Vopak, 60; ENAGAS, 40
Mexico	Regasification	Costa Azul	27 km northwest of Ensenada, Baja California	Sempra, 100
Mexico	Regasification	Manzanillo	Port of Manzanillo, Colima	Mitsui, 37.5; Samsung, 37.5; KOGAS, 25
Peru	Liquefaction	Peru LNG	Camisea terminal endpoint, north of Pisco	Hunt Oil, Shell, SK Corp., Marubeni
Trinidad and Tobago	Liquefaction	Atlantic LNG 1 (ALNG)	Point Fortin, Trinidad	BP, BG, Shell, CIC, NGC Trinidad
Trinidad and Tobago	Liquefaction	Atlantic LNG 2 (ALNG)	Point Fortin, Trinidad	BP, BG, Shell
Trinidad and Tobago	Liquefaction	Atlantic LNG 3 (ALNG)	Point Fortin, Trinidad	BP, BG, Shell
Trinidad and Tobago	Liquefaction	Atlantic LNG 4 (ALNG)	Point Fortin, Trinidad	BP, BG, Shell, CIC, NGC Trinidad

but for including the spatial footprint of the pipelines, all oil and gas pipelines are represented as a single feature class. The total length of all pipeline features in this feature class is over 93,000 km. Data on oil and gas pipelines were collected from a range of foreign governmental or company sources, including:

- Argentina—Ministerio de Energía y Minería, 2017
- Brazil—Agência Nacional de Energia Eléctrica, 2016
- Chile—Ministerio de Energía, 2017
- Mexico—Instituto Nacional de Estadística y Geografía, 2017
- Suriname—Staatsolie Maatschappij Suriname N.V., 2017
- Peru—Instituto Geográfico Nacional, 2015

It is known that Argentina, Colombia, Ecuador, and Venezuela have differentiated product pipelines, depending on the original source and form of the product (for example, gas-only or oil fields with sufficiently exploitable quantities of both oil and gas) as well as the destination market (internal consumption or shipment for export). Peru's Camisea Pipeline begins in the Ucayali Basin in Amazonian Peru at the San Martín gas field and ends at the Pacific Ocean at the Pisco fractioning plant and Peru LNG facility for export. Production from the gas fields began in 2004, and this pipeline continues to supply over 95 percent of Peru's internal demand for gas while exporting more than 5.6 billion cubic meters annually of LNG to Mexico (Oil & Gas Year Ltd., The, 2015). Other networks of pipelines exist on the Atlantic coast of Argentina, Brazil, and Uruguay, serving that part of the region's major metropolitan markets. One example of a major interntional pipeline is the Cruz del Sur pipeline, operated by Gasoducto Cruz del Sur S.A. Crossing under the Río de la Plata from Punta Lara, Argentina, and eventually reaching Montevideo, Uruguay, the 24-inch-diameter, 57-km-long pipeline is an extension of Argentina's natural gas grid to deliver natural gas to Uruguayan customers (Gasoducto Cruz del Sur S.A., 2017).

Oil and gas cumulative production and rank, recoverable proven plus probable hydrocarbon resources, and undiscovered hydrocarbon resources from IHS IEPD and USGS—*D_IHS_USGS_OG_DATA* feature dataset

Overview of hydrocarbon data from IHS IEPD and USGS—*OG_COUNTRY* and *OG_PETRO_PROV* feature classes

Working in collaboration with the USGS Energy Resources Program, the NMIC obtained permission from IHS IEPD[11] to use data from the IHS International Exploration and Production Database (IEPD) on hydrocarbon production within the region (IHS Global Inc., 2016). These data were originally individual records from oil fields or gas-only fields that were then aggregated by the USGS into country or petroleum province totals based on hydrocarbon product or resource category. For this report, the term "oil field" refers to those underground petroleum reservoirs that contain oil, natural gas, and condensate or natural gas liquids; whereas "gas-only" fields contain little to no exploitable oil. Within the geodatabase, the *D_IHS_USGS_OG_DATA* feature dataset contains two feature classes with extensive data attribute tables, *OG_COUNTRY* and *OG_PETRO_PROV*, which contain the IHS IEPD data organized by country or petroleum province, respectively.

Table 20 shows the simplified schema for the user-defined attribute field names for *OG_COUNTRY* and *OG_PETRO_PROV* within the file geodatabase. These data are organized by cumulative production and recoverable proven plus probable resources based on the following hydrocarbon resource categories:

1. Conventional oil, gas, and condensate from oil fields, shown with the field alias prefix "CONV_"
2. Conventional gas and condensate from gas-only fields, shown with the field alias prefix "CONV_GASO_"
3. Extra-heavy crude resources from oil fields, shown with the field alias prefix "XHC_"
4. Unconventional oil, gas, and condensate resources from oil fields, shown with the field alias prefix "UNCONV_"

There is a fifth grouping of data attribute fields at the end of each table which are not IHS IEPD data but instead are derived from the USGS 2012 world assessment of undiscovered, technically recoverable conventional oil and gas resources (Data Series 69–FF; U.S. Geological Survey World Conventional Resources Assessment Team, 2013). The format is similar although the terminology differs slightly from that of IHS IEPD, using the term "natural gas liquids" (NGL), which includes condensates but which also may include other natural gas liquids. These data also include total oil equivalent (TOE) for all hydrocarbon resources, as well as a generalized category for any offshore resources that are not allocated at a country level. These data do not have a prefix, but begin with the "OO_MCM" data field.

Two USGS-created fields per hydrocarbon resource product category that are not part of the original numeric IHS IEPD or USGS data are included: (a) fields beginning with "CAT," showing a USGS-created categorization schema for simplified cartographic visualization, and (b) fields beginning with "RANK," indicating the USGS-calculated regional rank. "CAT" fields are categorized by magnitude of production, regardless of the units of measurement used within a particular hydrocarbon resource's numeric data fields. Natural gas liquids (from USGS) and oil are reported in million cubic meters, whereas condensate (from IHS IEPD) and gas are reported in billion cubic meters. Data were not converted into one magnitude to preserve original reported data precision.

For example, category "A" refers to the largest category of production by magnitude, values greater than 10,000 million (or billion) cubic meters. Category "B" refers to values between 1,000 and 9,999 million (or billion) cubic meters. Category "C" refers to values between 100 and 999 million (or billion) cubic meters. Category "D" refers to values between 1 and 99 million (or billion) cubic meters. Category "E" refers to values that are less than one unit (marked as "LT1," meaning less than one million (or billion) cubic meters). The value "NA" denotes when data were not available or applicable. The value "W" denotes when a value is withheld to protect proprietary information or when there is only one field reporting per geographic area (country or petroleum province).

Data records were ranked in order of largest to smallest reported volume of production or resource, either in million or billion cubic meters, and results tabulated in the "RANK" field. Appropriate units are included in the field alias for quick reference as a alias suffix of either "_MCM" or "_BCM." Rankings are regional and based only on those geographic units included in this report (that is, country or petroleum province) and do not reflect global totals of hydrocarbon production. Fields beginning with "CAT" and "RANK" are numerically titled (for example, "CAT1," "RANK1," "CAT2," "RANK2," etc.) and refer to the data column that they immediately follow.

[11]As stated in the section on petroleum provinces, the IHS International Exploration and Production Database (IEPD) was accessed by USGS Energy Resources Program researchers when the company conducted business as IHS Global. In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit.

Table 20. User-defined attribute fields in the *OG_COUNTRY* and *OG_PETRO_PROV* data feature classes.

[NA, not applicable; PP, petroleum province]

Field name abbreviation in *LAC_Indust_Infra.gdb*	Field name or description	Comment	Data source	Attribute field included in geospatial PDF map
COUNTRY (OG_COUNTRY only)	Country of interest		NA	Yes
USGS_PP_CODE (OG_PETRO_PROV only)	Petroleum province code	USGS petroleum province code, from USGS Energy Resources Program	USGS	Yes
USGS_PP_NAME (OG_PETRO_PROV only)	Petroleum province name	USGS petroleum province name, from USGS Energy Resources Program	USGS	Yes
CONV_OILFLD	Conventional oil field production fields	Count of individual fields included within the country or petroleum province; data withheld for less than one field	IHS IEPD	Yes
CONV_OILCM_MCM	Conventional cumulative oil production from oil fields, in million cubic meters	Conventional oil production, in million cubic meters	IHS IEPD	Yes
CAT1	Magnitude of production category field	Production category for CONV_OILCM_MCM	USGS	Yes
RANK1	Ranking field	Numeric ranking from largest to smallest for conventional oil production as shown in CONV_OILCM_MCM	USGS	Yes
CONV_OILRPP_MCM	Recoverable proven plus probable resource total for conventional oil from oil fields, in million cubic meters	Recoverable proven plus probable resource total for conventional oil from oil fields	IHS IEPD	Yes
CAT2	Magnitude of production category field for second data field	Production category for CONV_OILRPP_MCM	USGS	Yes
RANK2 (This pattern of a “CAT” field and a “RANK” field following a data field repeats for all the following data fields for both OG_COUNTRY and OG_PETRO_PROV tables.)	Ranking field for second data field	Numeric ranking from largest to smallest for conventional oil production as shown in CONV_OILRPP_MCM	USGS	Yes
CONV_GASCM_BCM	Conventional cumulative gas production from oil fields, in billion cubic meters		IHS IEPD	No
CONV_GASRPP_BCM	Recoverable proven plus probable resource total for conventional gas from oil fields, in billion cubic meters		IHS IEPD	No
CONV_CNDCM_BCM	Conventional cumulative condensate production from oil fields, in billion cubic meters		IHS IEPD	No

Table 20. User-defined attribute fields in the *OG_COUNTRY* and *OG_PETRO_PROV* data feature classes.—Continued

[NA, not applicable; PP, petroleum province]

Field name abbreviation in *LAC_Indust_Infra.gdb*	Field name or description	Comment	Data source	Attribute field included in geospatial PDF map
CONV_CNDRPP_BCM	Recoverable proven plus probable resource total for conventional condensate from oil fields, in billion cubic meters		IHS IEPD	No
CONV_GASOFLD	Conventional gas-only field production fields	Count of individual fields included within the country or petroleum province; data withheld for less than one field	IHS IEPD	No
CONV_GASOCM_BCM	Conventional cumulative gas production from gas-only fields, in billion cubic meters		IHS IEPD	No
CONV_GASORPP_BCM	Recoverable proven plus probable resource total for conventional gas from gas-only fields, in billion cubic meters		IHS IEPD	No
CONV_GASO_CNDCM_BCM	Conventional cumulative condensate production from gas-only fields, in billion cubic meters		IHS IEPD	No
CONV_GASO_CNDRPP_BCM	Recoverable proven plus probable resource total for conventional condensate from gas-only fields, in billion cubic meters		IHS IEPD	No
XHC_OILFLD	Extra-heavy crude petroleum oil fields	Count of individual fields included within the country or petroleum province; data withheld for less than one field	IHS IEPD	No
XHC_OILCM_MCM	Conventional cumulative production of oil from extra-heavy crude resources from oil fields, in million cubic meters		IHS IEPD	No
XHC_OILRPP_MCM	Recoverable proven plus probable resource total for oil from extra-heavy crude resources from oil fields, in million cubic meters		IHS IEPD	No
XHC_GASCM_BCM	Conventional cumulative production of gas from extra-heavy crude resources from oil fields, in billion cubic meters		IHS IEPD	No
XHC_GASRPP_BCM	Recoverable proven plus probable resource total for gas from extra-heavy crude resources from oil fields, in billion cubic meters		IHS IEPD	No
XHC_CNDCM_BCM	Conventional cumulative production of condensate from extra-heavy crude resources from oil fields, in billion cubic meters		IHS IEPD	No

Table 20. User-defined attribute fields in the *OG_COUNTRY* and *OG_PETRO_PROV* data feature classes.—Continued

[NA, not applicable; PP, petroleum province]

Field name abbreviation in *LAC_Indust_Infra.gdb*	Field name or description	Comment	Data source	Attribute field included in geospatial PDF map
XHC_CNDRPP_BCM	Recoverable proven plus probable resource total for condensate from extra-heavy crude resources from oil fields, in billion cubic meters		IHS IEPD	No
UNCONV_OILFLD	Unconventional petroleum resource oil fields	Count of individual fields included within the country or petroleum province; data withheld for less than one field	IHS IEPD	No
UNCONV_OILCM_MCM	Conventional cumulative production of oil from unconventional resources from oil fields, in million cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
UNCONV_OILRPP_MCM	Recoverable proven plus probable resource total for oil from unconventional resources from oil fields, in million cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
UNCONV_GASCM_BCM	Conventional cumulative production of gas from unconventional resources from oil fields, in billion cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
UNCONV_GASRPP_BCM	Recoverable proven plus probable resource total for gas from unconventional resources from oil fields, in billion cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
UNCONV_CNDCM_BCM	Conventional cumulative production of condensate from unconventional resources from oil fields, in billion cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
UNCONV_CNDRPP_BCM	Recoverable proven plus probable resource total for condensate from unconventional resources from oil fields, in billion cubic meters	Unconventional resources include coalbed methane, shale gas, tight gas, shale oil, and tight oil	IHS IEPD	No
OO_MCM	Oil from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in million cubic meters		USGS	No
GO_BCM	Gas from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in billion cubic meters		USGS	No
NGLO_MCM	Natural gas liquids from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in million cubic meters		USGS	No

Table 20. User-defined attribute fields in the *OG_COUNTRY* and *OG_PETRO_PROV* data feature classes.—Continued

[NA, not applicable; PP, petroleum province]

Field name abbreviation in *LAC_Indust_Infra.gdb*	Field name or description	Comment	Data source	Attribute field included in geospatial PDF map
GG_BCM	Gas from gas-only fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in billion cubic meters		USGS	No
NGLG_MCM	Natural gas liquids from gas-only fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in million cubic meters		USGS	No
TOT_GAS_BCM	Total gas from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in billion cubic meters		USGS	No
TOT_NGL_MCM	Total natural gas liquids from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in million cubic meters		USGS	No
TOT_OE_MCM	Total oil equivalent from oil fields, used for undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, in million cubic meters		USGS	No

IHS IEPD data as displayed on the geospatial PDF map

For the geospatial PDF map, example map layers were drawn to show the rank and magnitude of the oil and gas production and resource data. These layers consist of (i) cumulative production of conventional oil by country, (ii) cumulative production of conventional oil by petroleum province, (iii) recoverable proven plus probable (RPP) hydrocarbon resources by country, and (iv) RPP by petroleum province. The layers are organized into two folders labelled “Cumulative Production” and “Recoverable Proven Plus Probable,” with the individual layers including “by country” or “by petroleum province” in the layer name. Owing to file size limitations within the geospatial PDF, the entire *OG_COUNTRY* and *OG_PETRO_PROV* feature classes are not visually drawn within the map, but a user having access to Esri ArcGIS would be able to generate similar categorized and ranked maps, or use the tabular data to generate analyses in a similar fashion.

Additional information and data tables for *OG_COUNTRY* and *OG_PETRO_PROV*

Within this report, the *OG_COUNTRY* and *OG_PETRO_PROV* feature classes were organized into a more readable format, to assist users not having access to the geodatabase data table. This was done to also show the data in a more specific format for the five hydrocarbon resource categories (four from IHS IEPD, one from USGS), as compared to the full data tables in the geodatabase that have over 50 data fields per feature class. For explanatory purposes, five data tables by country and five data tables by petroleum province were created to include in this report. Oil and gas production from unconventional sources includes shale oil, shale gas, coalbed methane, tight gas, and tight oil resources, whereas conventional excludes all of these categories.

Cumulative production is defined at the oil or gas field level and is cumulative from the time the field began production; thus, for the country and petroleum province level, production start dates vary based on the constituent fields within that geographic area. The ending time period for the most recent report of cumulative production was either 2014 or 2015 for 95 percent of the individual fields within this dataset. A gas field is defined as a field having a gas-to-oil ratio (GOR) greater than or equal to 20,000 cubic feet of gas at standard conditions to one stock barrel of oil, using industry-accepted conventional American oil field units.[12] Historically, non-associated gas in gas-only fields was considered less economical for recovery, so associated gas production is greater from oil fields. Data may be withheld for individual geographic areas (countries or petroleum provinces) to conceal and protect proprietary data.

Table 21 shows cumulative production data and RPP resources for conventional hydrocarbon resources from oil fields by country, and table 22 shows the same by petroleum province. These two tables show example data from the IHS IEPD portion of the database. Table 23 and table 24 show the mean volumes of undiscovered, technically recoverable conventional hydrocarbon resources from oil fields by country and by petroleum province, respectively, as examples of the

[12]In this report, the term "standard conditions" refers to standard temperature and pressure and is defined by the Society of Petroleum Engineers as 14.7 pounds per square inch and 60 °F when gas volumes are reported in industry-accepted conventional American oil field units. For the metric system, standard conditions are defined as 15 °C and 1 atmosphere (Society of Petroleum Engineers, 2001, p. 31).

Table 21. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from oil fields, by country within Latin America and the Caribbean, from the *OG_COUNTRY* feature class.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for total of number of fields]

Country	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
Argentina	825	1,490	1,960	372	503	3	6
Barbados	16	2	3	LT1	1	LT1	LT1
Belize	4	1	4	NA	LT1	NA	NA
Bolivia	39	45	54	27	47	3	5
Brazil	827	2,380	14,100	386	3,680	LT1	72
Chile	100	38	50	36	54	NA	LT1
Colombia	518	1,380	1,920	176	296	NA	9
Costa Rica	1	NA	NA	NA	NA	NA	NA
Cuba	35	57	96	1	16	NA	NA
Dominican Republic	2	NA	LT1	NA	NA	NA	NA
Ecuador	186	901	1,490	33	72	NA	NA
Falkland Islands / Islas Malvinas (United Kingdom)	4	NA	72	NA	13	NA	LT1
French Guiana	1	NA	NA	NA	NA	NA	NA
Guatemala	14	25	37	NA	1	NA	NA
Guyana	2	NA	32	NA	3	NA	NA
Mexico	459	6,790	9,340	1,500	2,200	LT1	LT1
Nicaragua	4	NA	LT1	NA	LT1	NA	NA
Paraguay	NA	NA	NA	NA	NA	NA	NA
Peru	118	430	740	52	158	NA	LT1
Suriname	4	17	20	NA	LT1	NA	NA
Trinidad and Tobago	74	582	665	140	236	NA	LT1
Venezuela	375	10,300	16,000	2,380	4,940	52	367
Total	**3,608**	**24,500**	**46,600**	**5,100**	**12,200**	**58**	**461**

Table 22. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean, from the *OG_PETRO_PROV* feature class.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
5300	Burgos Basin	9	LT1	42	LT1	12	NA	LT1
5301	Tampico-Misantla Basin	183	955	1,610	230	532	NA	LT1
5302	Veracruz Basin	19	13	28	7	13	NA	LT1
5304	Saline-Comalcalco Basin	102	447	676	90	125	NA	LT1
5305	Villahermosa Uplift	137	5,360	6,970	1,160	1,520	NA	LT1
5306	Macuspana Basin	3	5	7	2	2	LT1	LT1
5307	Campeche-Sigsbee Salt Basin	2	NA	4	NA	LT1	NA	NA
5308	Yucatán Platform	8	22	30	NA	LT1	NA	NA
5310	Sierra Madre de Chiapas-Peten Foldbelt	13	5	11	LT1	LT1	NA	NA
5313	Sierra Madre Oriental Foldbelt	1	NA	W	NA	W	NA	NA
5314	Jalisco-Oaxaca Platform	NA	NA	NA	NA	NA	NA	NA
5321	Coahuila Platform	NA	NA	NA	NA	NA	NA	NA
5323	Sabinas Basin	NA	NA	NA	NA	NA	NA	NA
5332	Salton Trough	NA	NA	NA	NA	NA	NA	NA
5334	Vizcaíno Basin	NA	NA	NA	NA	NA	NA	NA
6010	Takutu Basin	1	NA	W	NA	W	NA	NA
6011	Solimões Basin	7	42	58	56	78	NA	3
6012	Amazonas Basin	5	NA	LT1	NA	LT1	NA	NA
6016	Parnaíba Basin	NA	NA	NA	NA	NA	NA	NA
6020	Paraná Basin	2	NA	LT1	NA	LT1	NA	NA
6021	Guyana-Suriname Basin	6	17	76	NA	4	NA	NA
6022	Foz do Amazonas Basin	2	NA	LT1	NA	NA	NA	NA
6023	Santana Platform	4	NA	13	NA	4	NA	NA
6025	Barreirinhas Basin	3	LT1	LT1	LT1	LT1	NA	NA
6026	Ceará Basin	21	23	47	3	6	NA	LT1
6027	Potiguar Basin	163	134	319	25	68	NA	2
6029	Sergipe-Alagoas Basin	94	126	420	45	124	LT1	6
6031	Tucano Basin	1	NA	W	NA	W	NA	NA
6032	Recôncavo Basin	134	256	316	64	76	LT1	LT1
6033	Bahia Sul Basin	21	LT1	7	LT1	LT1	NA	NA
6034	Espírito Santo Basin	110	50	446	7	59	LT1	LT1
6035	Campos Basin	188	1,700	4,510	174	475	NA	LT1
6036	Santos Basin	72	49	7,960	11	2,790	LT1	61
6038	Santiago Basin	NA	NA	NA	NA	NA	NA	NA
6039	Huallaga Basin	NA	NA	NA	NA	NA	NA	NA

Table 22. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean, from the *OG_PETRO_PROV* feature class.—Continued

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
6040	Ucayali Basin	9	5	11	NA	LT1	NA	NA
6041	Putumayo-Oriente-Maranon Basin	267	1,120	1,870	45	91	NA	NA
6043	Madre dos Dios Basin	1	NA	W	NA	W	NA	NA
6044	Beni Basin	1	NA	W	NA	W	NA	NA
6045	Santa Cruz-Tarija Basin	49	49	59	28	48	3	5
6046	Oran-Olmedo Basin	35	22	29	5	6	NA	NA
6051	Cuyo Basin	46	221	258	9	11	NA	NA
6055	Neuquén Basin	419	522	636	200	252	2	3
6058	San Jorge Basin	217	655	951	114	168	NA	LT1
6059	Magallanes Basin	194	104	129	80	120	1	2
6060	Falklands Plateau	4	NA	72	NA	13	NA	LT1
6063	Malvinas Basin	2	NA	LT1	NA	LT1	NA	NA
6065	Altiplano Basin	1	W	W	NA	NA	NA	NA
6069	Temuco Basin	NA	NA	NA	NA	NA	NA	NA
6074	Central Chile Forearc Basin	NA	NA	NA	NA	NA	NA	NA
6080	Sechura Basin	NA	NA	NA	NA	NA	NA	NA
6081	Talara Basin	58	256	393	48	143	NA	LT1
6083	Progreso Basin	16	23	48	5	13	NA	LT1
6087	Choco Pacific Basin	2	NA	LT1	NA	LT1	NA	NA
6089	Upper Magdalena Valley Basin	57	139	174	11	37	NA	LT1
6090	Middle Magdalena Valley Basin	100	406	528	93	110	NA	LT1
6091	Lower Magdalena Valley Basin	9	11	12	7	7	NA	NA
6093	Perijá-Venezuela-Coastal Ranges	1	W	W	NA	NA	NA	NA
6094	Cesar Basin	1	NA	W	NA	W	NA	NA
6095	Guarija Basin	1	NA	W	NA	W	NA	NA
6096	Llanos Basin	295	793	1,180	38	110	NA	8
6097	Barinas-Apure Basin	16	135	372	4	5	NA	LT1
6098	East Venezuela Basin	347	3,680	5,940	1,400	3,180	33	293
6099	Maracaibo Basin	71	7,020	10,200	1,120	1,970	19	74
6100	Falcon Basin	16	19	32	3	14	NA	LT1
6102	Cariaco Basin	4	NA	14	NA	11	NA	LT1
6103	Tobago Trough	NA	NA	NA	NA	NA	NA	NA
6104	South Caribbean Deformed Belt	NA	NA	NA	NA	NA	NA	NA

Table 22. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean, from the *OG_PETRO_PROV* feature class.—Continued

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
6106	West-Central Cordillera	2	NA	LT1	NA	LT1	NA	NA
6107	Lesser Antilles Deformed Belt	16	2	3	LT1	1	LT1	LT1
6114	North Nicaraguan Rise	3	NA	LT1	NA	LT1	NA	NA
6117	Greater Antilles Deformed Belt	37	57	96	LT1	16	NA	NA
Total		**3,608**	**24,400**	**46,600**	**5,090**	**12,200**	**58**	**461**

Table 23. Total mean volumes of undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, by country within Latin America and the Caribbean, from the *OG_COUNTRY* feature class.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil, natural gas liquids, and total oil equivalent in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for total of number of fields]

Country	Oil from oil fields (MCM)	Gas from oil fields (BCM)	Natural gas liquids from oil fields (MCM)	Gas from gas-only fields (BCM)	Natural gas liquids from gas-only fields (MCM)	Total gas (BCM)	Total natural gas liquids (MCM)	Total oil equivalent (MCM)
Argentina	78	22	2	270	42	293	44	396
Barbados	LT1	LT1	LT1	3	LT1	3	LT1	3
Belize	25	9	LT1	LT1	LT1	9	LT1	35
Bolivia	15	11	1	651	160	662	161	795
Brazil	710	1,010	140	1,410	236	2,400	376	3,350
Chile	11	5	LT1	38	6	43	7	58
Colombia	875	224	38	214	87	439	124	1,410
Cuba	50	6	LT1	LT1	LT1	6	LT1	56
Ecuador	37	3	LT1	LT1	LT1	3	LT1	41
Guatemala	56	10	1	LT1	LT1	10	1	67
Guyana	7	2	LT1	LT1	LT1	3	LT1	10
Mexico	632	202	34	585	72	788	106	1,480
Offshore	58,400	22,000	3,430	95,600	16,000	118,000	19,400	188,000
Paraguay	2	2	LT1	14	3	16	4	21
Peru	426	35	5	LT1	LT1	35	5	463
Suriname	7	2	LT1	LT1	LT1	3	LT1	10
Trinidad and Tobago	3	LT1	LT1	2	LT1	3	LT1	6
Venezuela	427	213	34	255	52	468	86	951
Total	**61,761**	**23,800**	**3,690**	**99,000**	**16,600**	**123,000**	**20,300**	**197,000**

Table 24. Total mean volumes of undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean, from the *OG_PETRO_PROV* feature class.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil, natural gas liquids, and total oil equivalent in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Oil from oil fields (MCM)	Gas from oil fields (BCM)	Natural gas liquids from oil fields (MCM)	Gas from gas-only fields (BCM)	Natural gas liquids from gas-only fields (MCM)	Total gas (BCM)	Total natural gas liquids (MCM)	Total oil equivalent (MCM)
5300	Burgos Basin	980	209	24	365	59	575	82	1,600
5301	Tampico-Misantla Basin	866	286	49	402	59	688	108	1,600
5302	Veracruz Basin	15	4	LT1	246	7	250	7	256
5303	Tuxtla Uplift	4	LT1	LT1	26	LT1	27	LT1	30
5304	Saline-Comalcalco Basin	181	59	25	21	LT1	80	25	281
5305	Villahermosa Uplift	227	130	8	92	11	222	19	453
5306	Macuspana Basin	4	4	LT1	12	LT1	16	LT1	19
5307	Campeche-Sigsbee Salt Basin	455	269	10	122	14	390	24	845
5308	Yucatán Platform	205	84	5	LT1	LT1	84	5	289
5310	Sierra Madre de Chiapas-Peten Foldbelt	148	21	4	LT1	LT1	21	4	172
6006	Andean Province	LT1	LT1	LT1	28	7	29	7	34
6011	Solimões Basin	91	132	18	523	81	655	99	804
6012	Amazonas Basin	59	85	12	188	29	273	41	356
6016	Parnaíba Basin	473	685	95	503	78	1,200	173	1,760
6020	Paraná Basin	68	99	14	187	46	286	60	396
6021	Guyana-Suriname Basin	2,200	606	92	489	97	1,100	190	3,400
6022	Foz do Amazonas Basin	62	17	3	545	154	563	157	746
6023	Santana Platform	26	7	1	230	65	237	66	314
6029	Sergipe-Alagoas Basin	316	126	43	110	38	236	81	617
6034	Espírito Santo Basin	303	114	12	419	85	533	97	899
6035	Campos Basin	2,300	781	132	150	27	931	158	3,370
6036	Santos Basin	9,500	4,200	685	1,760	295	6,000	980	16,000
6037	Pelotas Basin	124	51	18	533	65	584	83	754
6041	Putumayo-Oriente-Maranon Basin	747	61	9	LT1	LT1	61	9	813
6044	Beni Basin	LT1	LT1	LT1	21	5	21	5	26
6045	Santa Cruz-Tarija Basin	18	13	2	680	167	693	168	834
6046	Oran-Olmedo Basin	LT1	LT1	LT1	8	2	8	2	9
6054	Salado-Punta del Este Basin	107	44	15	214	26	258	41	389
6055	Neuquén Basin	53	14	2	107	9	121	11	177

Table 24. Total mean volumes of undiscovered, technically recoverable conventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean, from the *OG_PETRO_PROV* feature class.—Continued

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc. (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil, natural gas liquids, and total oil equivalent in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Oil from oil fields (MCM)	Gas from oil fields (BCM)	Natural gas liquids from oil fields (MCM)	Gas from gas-only fields (BCM)	Natural gas liquids from gas-only fields (MCM)	Total gas (BCM)	Total natural gas liquids (MCM)	Total oil equivalent (MCM)
6058	San Jorge Basin	11	1	LT1	6	LT1	7	LT1	18
6059	Magallanes Basin	33	14	LT1	167	28	181	29	231
6060	Falklands Plateau	843	342	25	1,100	163	1,440	187	2,380
6061	East Patagonia Basin	207	86	29	415	51	500	80	755
6063	Malvinas Basin	22	9	LT1	163	27	173	28	211
6089	Upper Magdalena Valley Basin	62	16	2	14	1	30	3	93
6090	Middle Magdalena Valley Basin	85	27	2	19	2	46	4	131
6091	Lower Magdalena Valley Basin	15	8	LT1	84	35	92	36	137
6095	Guarija Basin	10	5	LT1	68	8	73	9	87
6096	Llanos Basin	424	148	28	90	54	238	82	728
6097	Barinas-Apure Basin	88	1	LT1	25	1	26	2	114
6098	East Venezuela Basin	537	323	40	820	129	1,140	168	1,780
6099	Maracaibo Basin	148	55	13	169	27	225	40	398
6103	Tobago Trough	LT1	LT1	LT1	446	10	446	10	427
6107	Lesser Antilles Deformed Belt	24	9	2	413	55	422	57	476
6117	Greater Antilles Deformed Belt	894	265	132	109	17	375	150	1,400
6119	Bahama Platform	53	12	4	36	3	48	8	105
Total		**23,000**	**9,400**	**1,560**	**12,000**	**2,000**	**22,000**	**3,600**	**47,000**

USGS data that comprise the last fields in the *OG_COUNTRY* and *OG_PETRO_PROV* feature classes.

Additional tables in appendix 1 (data tables 1–1 through 1–7) follow this layout, for both country and petroleum province data, for the other hydrocarbon resource categories from IHS IEPD: (i) conventional hydrocarbon production and RPP resources for gas-only fields, (ii) extra-heavy crude resources from oil fields, and (iii) unconventional resources.

Venezuela leads the region for cumulative conventional oil production from oil fields, with over 10 billion cubic meters (BCM) produced, followed by Mexico (6.8 BCM), Brazil (2.4 BCM), Argentina (1.5 BCM), and Colombia (1.4 BCM). This order is nearly identical for recoverable proven plus probable conventional oil resources, with Venezuela containing over 16 BCM of resources, followed by Brazil (14 BCM), Mexico (9 BCM), Argentina (2 BCM), and Colombia (1.9 BCM).

As shown in table 22, the Maracaibo Basin in Venezuela, which includes Lake Maracaibo, ranked first for cumulative conventional oil production by petroleum province, with over 7 BCM produced since production began. The Villahermosa Uplift, which includes producing areas near Paraíso, Tabasco State, Mexico, was second, with 5.4 BCM produced, followed by the East Venezuela Basin, which includes the Orinoco Oil Belt, with 3.7 BCM. The fourth ranked petroleum province was the Campos Basin off the coast of Rio de Janeiro State in Brazil, with approximately 1.7 BCM produced. Similar to the country-level data, these petroleum provinces are also among the top five for recoverable proven plus probable conventional oil resources: the Maracaibo Basin with 10.2 BCM of RPP resources, the Santos Basin offshore of the States of Rio de Janeiro and São Paulo with almost 8 BCM, the Villahermosa Uplift with almost 7 BCM, the East Venezuela Basin with almost 6 BCM, and the Campos Basin with 4.5 BCM. The

Santos Basin ranked 22d for cumulative conventional oil production but has been the site of intensive oil and gas exploration owing to its significant resources (Queiroz Galvão, 2016).

The undiscovered, technically recoverable conventional oil and gas resources data from the USGS 2012 world assessment (U.S. Geological Survey World Conventional Resources Assessment Team, 2013), as stated above, are very similar to the IHS IEPD data, although they employ different terminology. By country, the greatest total oil equivalent (TOE) for undiscovered, technically recoverable resources occurs in offshore areas that were not correlated to any specific country, at almost 188 BCM (table 23). Undiscovered, technically recoverable conventional offshore oil-only resources accounted for 58 BCM, or about 30 percent of the TOE for offshore areas. Onshore areas of Brazil accounted for the second-leading area for undiscovered resources, with about 3.4 BCM of TOE present, followed by onshore areas of Mexico (about 1.5 BCM) and Colombia (1.4 BCM).

As shown in table 24, by petroleum province, the greatest total oil equivalent (TOE) for undiscovered, technically recoverable resources occurs in the Santos Basin, at 16 BCM, followed by the Guyana-Suriname Basin offshore of the coasts of French Guiana, Guyana, and Suriname at 3.4 BCM; then the Campos Basin at slightly less than 3.4 BCM, the Falklands Plateau surrounding the Falkland Islands (an overseas territory of the United Kingdom, also known as Islas Malvinas) at 2.4 BCM, and the East Venezuela Basin at 1.8 BCM. The significant potential for all of these areas to contain additional hydrocarbon resources has been well documented throughtout industry literature, with considerable investment made by domestic and foreign companies looking to continue to explore and discover potentially economically exploitable resources, including those in deepwater and super-deepwater conditions.

Transportation infrastructure—*E_TRANSPOR_INFRA* feature dataset

The feature dataset *E_TRANSPOR_INFRA* contains one vector point feature class for mineral commodity exporting ports and one vector polyline feature class for railroads.

Railroads—*RAIL* feature class

The *RAIL* feature class originates from the 1992 version of the Digital Chart of the World (DCW), produced by the U.S. Defense Mapping Agency, which is now the National Geospatial-Intelligence Agency (NGA) (National Geospatial-Intelligence Agency [formerly U.S. National Imagery and Mapping Agency], 1992). It is included for visual spatial reference and does not contain attribute information. While almost three decades old, the DCW is still one of the best generalized representations of approximate coverage of railroads worldwide. Some countries, notably Brazil, may have built railroads in the subsequent intervening time period; however, a rail-by-rail analysis and digitization effort was not possible for this project. Approximately 150,000 km of rail polylines are included in this feature class.

Rail ownership and operations within several countries have had periods of privatization and nationalization over the second half of the 20th century and into the 21st century. Brazil, for example, had a state-owned rail system that was nationalized in 1957 into the Rede Ferroviária Federal, S.A. (RFFSA) and operated under government control until 1999. At that time the system's assets were liquidated and leased to the following private companies for a 30-year period, with the possibility of renewal for an additional 30-year period: Northeastern Railway Co. (CFN), Atlantic Central Railroad (FCA), MRS Logística S.A., Ferrovia Bandeirantes (Ferroban), Ferrovia Novoeste S.A., Latin America and Logistics (ALL), and Ferrovia Teresa Cristina S.A. (Rede Ferroviária Federal, S.A., 2007; Ministério dos Transportes, Portos e Aviação Civil, 2014). Similarly in Argentina, Ferrocarriles Argentinos S.A. (FA) was a state-owned company formed in 1948 which operated both passenger and freight services. In 1993, privatization of FA occurred, with seven companies taking ownership of freight services throughout the country. In 2015, the railways were re-nationalized under government control (Daily Ambito Financiero, 2015). Comparing these data from the DCW against Google Earth™ satellite imagery shows a rough approximation to on-the-ground paths of railroads, though some rail segments may have poorer locational accuracy than others and be farther off-course. However, at the regional scale, a visual comparison of the generalized rail paths to the mineral facility and other data feature classes shows a tight correlation between the locations of mines and mineral processing facilities and their degree of connectedness to the transportation network.

Mineral commodity exporting ports—*PORTS_LAC* feature class

The primary objective of constructing a ports feature class was to identify the maritime ports that export a significant contribution to the global supply of a subset of major primary mineral commodities that impact the global economy (table 25). The feature class comprises ports by name and location, their ownership or operating authority, primary mineral commodities exported, specific form of the mineral commodity, estimated annual export tonnage (estimated as the average for the years 2010–12), sources of the commodity (mine, smelter, or refinery, if known), and the destination country or countries of exports. This feature class includes 74 unique ports and 46 mineral commodities or commodity groupings, with a total record count of 230 data entries. Some mineral commodity groupings are shown by the primary metal in the "COMM_EXPD" (or "commodity exported") field, such as copper, with more specific forms of products listed in the "FORM_COMM" (or "form of commodity") field. Examples of a more specific form of copper exported include: anode copper, cathode copper, concentrates, ores and concentrates, refined metal, and wire. The majority of metals, such as

Table 25. Description of user-defined attribute fields in the mineral commodity exporting ports feature class *PORTS_LAC*.

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
ROWID	Row ID	Numeric (integer)	Unique ID number for each row	Sequential order, ascending	No
GENC_CC	GENC country code	Text	GENC two-digit country code	Unique to each country	No
FACID_NUM	Facility ID number	Numeric (integer)	Unique ID number per facility per country	Sequential order, ascending; restarts for each country	No
FACID	Facility ID	Alphanumeric	GENC_CC combined with FACID_NUM Used as labels on map.	Sequential order, ascending	Yes
PORTPRODID	Port product ID	Alphanumeric	FACID field with an additional letter (a, b, c, …) to denote a unique export record	AA1a, AA1b, AA1c, AA1d, etc.[1]	Yes
WPICODE	World Port Index Code	Numeric	World Port Index number for a listed port	National Geospatial-Intelligence Agency's World Index Port Codeset	No
MULTIREC	Multiple records	Text	Multiple records are present for a single port	Flagged "Y" to indicate that this port has multiple records denoting multiple exports	Yes
NEWPORT	New port	Text	New port not in World Port Index	Flagged "Y" to indicate that this port is not in the original World Port Index but was added to this project owing to discovery of mineral commodity exports	No
COUNTRY	Country	Text	Country name	Country name	Yes
ADM1	First-order administrative division	Text	First-order administrative divisions are the equivalents of States in Brazil, Mexico, and the United States.	Codeset from National Geospatial-Intelligence Agency	No
PORTNAME	Port name	Text	Name of the port facility	Variable text	Yes
OWNER	Ownership	Text	Ownership information as from source material	Variable text	No
COMM_EXPD	Mineral commodity exported	Text	Mineral commodity exported from a port facility	Variable text	Yes
FORM_COMM	Product or form of the mineral commodity exported	Text	Product or form of the mineral commodity exported	Variable text	Yes
EST_ANN_TONN	Estimated annual tonnage	Text	Estimated annual tonnage of the listed product or form of mineral commodity exported	Variable numeric, thousand metric tons	Yes

Table 25. Description of user-defined attribute fields in the mineral commodity exporting ports feature class *PORTS_LAC*.—Continued

[ID, identification; GENC, Geopolitical Entities, Names, and Codes]

Data release and geodatabase field name	Field alias	Field type	Description	Examples of values (if applicable)	Attribute field included in geospatial PDF map
DEST	Destination countries or regions of the exported mineral commodity product	Text	Destination countries or regions of the exported mineral commodity product	Variable text	Yes
FEED_SOURCE	Source of feed material	Text	Source of feed material for the exported product, if known. May be a known mine, refinery, mining complex, general area, or company	Variable text	Yes
LOCACC	Locational accuracy	Text	Accuracy of the given coordinates for the facility	• A – Approximate location • E – Exact location	No
DDLAT	Latitude in decimal degrees	Numeric	Latitude in decimal degrees	Variable	No
DDLONG	Longitude in decimal degrees	Numeric	Longitude in decimal degrees	Variable	No
SOURCEID	Source/reference ID	Text	Source index number	Internal reference to sources for USGS	No

[1]For example, the feature class shows the FACID, or facility identification number, CL27 for the port of Mejillones, Chile. Mineral commodity products exported include copper cathodes (CL27a), silver-zinc concentrates (CL27b), lead-silver concentrates (CL27c), copper concentrates (CL27d), and molybdenum as contained in copper concentrates (CL27e).

copper, nickel, and zinc, are found to be contained within concentrates (either by gross weight or by content). Other mineral commodity categories, such as phosphate, include many specific downstream processed forms of minerals and materials, including diammonium phosphate, monoammonium phosphate, and trisodium phosphate.

This feature class presents data on mineral commodities in the primary form. Primary commodities refer to virgin materials such as ore, concentrates, other intermediate products, and refined metals originating from ore extraction activities. Exports of mineral commodities in the form of secondary materials, such as scrap aluminum and steel, were not specifically addressed. However, the tonnage of commodities recovered from scrap may be included in the exports of shipments from mineral processing plants that incorporate scrap into their feed (most likely including aluminum, copper, lead, and zinc smelters and refineries).

The primary source for the original port listing—the World Port Index (WPI)—was obtained from the National Geospatial-Intelligence Agency. Additional ports within the region were added if necessary during the course of research. The WPI did not contain any information about the mineral commodities exported but instead summarized the actual physical port characteristics, such as harbor depth and number of dockside servicing terminals. NMIC researchers investigated the specific mineral commodities, sometimes obtaining and verifying data contained within bills of lading from port authorities, and at other times using and verifying publicly available information contained in press reports and company websites. Table 25 describes the user-defined data attribute fields within the feature class and table 26 shows summary statistics. The full mineral commodity exporting port feature class, as well as metadata explaining all attribute field values, codes, and abbreviations, is available as a USGS data release (Baker and others, 2016) through the USGS ScienceBase data release page, available at https://doi.org/10.5066/F7BZ6460.

Due to relatively limited data availability on mineral commodity export details, forms of commodities exported vary. This dataset is not intended to be comprehensive in scope. It may be omitting ports or mineral commodities or forms of mineral commodities. Table 27 shows the total number of records per mineral commodity along with the number of different forms of the commodities.

Table 26. Summary statistics on mineral commodity exporting ports of Latin America and the Caribbean, 2010–12, from the *PORTS_LAC* feature class.

Country	Number of unique ports	Number of unique mineral commodity categories exported per country	Greatest number of export data records at single port	Port with greatest number of export data records
Argentina	2	3	2	Paraná
Brazil	13	22	12	Itaqui
Chile	19	17	11	Antofagasta
Colombia	8	3	3	Cartagena
Cuba	1	2	2	Moa
Dominican Republic	1	1	1	Haina
Ecuador	1	1	1	Manta
Guyana	1	1	3	Offshore bauxite transshipment terminal
Jamaica	5	4	4	Kingston
Mexico	12	19	23	Manzanillo
Peru	6	9	7	El Callao (near Lima)
Suriname	1	1	1	Paranam
Venezuela	4	4	2	Puerto Ordaz
Total	**74**			

Table 27. Mineral commodity-level statistics for mineral commodity exporting ports in Latin America and the Caribbean, 2010–12.—Continued

[NA, not applicable or not available]

Mineral commodity category exported	Total number of export records per mineral commodity category	Number of specific forms of the mineral commodity exported	Specific forms exported
Aggregate	2	2	Limestone, riverstone
Alumina	8	1	Alumina
Aluminum	4	3	Metal, metal and shapes
Barite	2	2	Barium carbonate, crude barite
Bauxite	5	4	Bauxite, chemical-grade bauxite, metallurgical-grade bauxite, refractory bauxite
Cadmium	1	1	Metal
Cement	10	3	Bulk, clinker, portland
Chromite	1	1	Ore
Clay	2	1	Bentonite
Coal	12	4	Anthracite, metallurgical and steam, unknown, thermal
Cobalt	1	1	Contained in unrefined nickel
Copper	41	5	Anode, cathode, concentrate (includes “concentrate (gross weight),” “contained in concentrate,” and “ores and concentrates”), refined metal, wire
Ferroalloys	7	4	Ferromanganese, ferronickel, ferroniobium, ferrosilicon
Fluorspar	4	2	Acid-grade, unknown (includes NA)
Gold	9	2	Contained in concentrate, contained in copper concentrates
Indium	2	2	In zinc concentrates, in Cajamarquilla zinc refinery residues

Table 27. Mineral commodity-level statistics for mineral commodity exporting ports in Latin America and the Caribbean, 2010–12.—Continued

[NA, not applicable or not available]

Mineral commodity category exported	Total number of export records per mineral commodity category	Number of specific forms of the mineral commodity exported	Specific forms exported
Iron	28	7	Dross, iron ore, lump ore and sinter feed (gross weight), ore, pellets, pig iron, sinter
Kaolin	2	1	Kaolin clay
Lead	9	3	Contained in concentrate, ingot, refined metal
Lead-silver	1	1	Concentrate
Lead-zinc	1	1	Concentrate
Lithium	3	3	Carbonate, chloride, hydroxide
Magnesium	3	2	Oxide, refined metal
Manganese	5	3	Ore, refined metal, unknown (includes NA)
Molybdenum	10	4	Concentrate, contained in copper concentrate, contained metal, refined metal
Nickel	4	4	Contained in matte, electrolytic, nickel contained in ferronickel, unrefined nickel and cobalt
Niobium	1	1	Niobium oxide
Phosphate	10	6	Dicalcium phosphate (DCP), diammonium, unspecified fertilizer (gross weight or tonnage), monoammonium phosphate, ore, trisodium phosphate (TSP)
Potash	2	1	Fertilizer (gross weight)
Potassium	3	3	Chloride, nitrate, sulfate
Salt	4	3	Bulk (various forms), rock, various forms
Selenium	1	1	Metal
Silver	6	1	Contained in copper concentrates
Silver-zinc	1	1	Concentrate
Soda ash	1	1	NA
Steel	1	1	Unspecified steel products
Stone	2	2	Limestone and a grouping of “granite, marble, quartz, slate, and travertine”
Tin	1	1	Metal
Titanium	2	2	Dioxide, mineral sands
Vanadium	1	1	Concentrate
Zinc	14	5	Concentrate, ingots, metal and refined metal, oxide, unwrought

Cartographic elements—*F_CARTO* feature dataset

Cartographic elements—*CITIES*, *COUNTRY*, *LAC_ELEVATION*, *RIVERS*, *USA* feature classes

Base cartographic elements were incorporated from a range of copyright-free or open-source shapefiles to represent political and physical features. International boundaries were derived from the U.S. Department of State (DOS)’s Large-Scale International Boundary (LSIB) dataset. The LSIB was created by DOS’s Office of the Cartographer and is one of the most accurate worldwide international boundary vector line files available (U.S. Department of State, 2017). These data include the World Vector Shoreline data and are an up-to-date representation of international boundaries. Physical and political features such as major rivers, capital cities, and other cities in the region were derived from base Esri files contained as part of their Data and Maps package, with additional regional cities of local importance added to the feature class via Google Earth™ for spatial reference. The *LAC_ELEVATION* feature class is a digital elevation model (DEM) that was created from original 90-meter data resampled to 250-meter resolution, obtained from the Consortium of International Agricultural Research Centers' Consortium for Spatial Information (CGIAR-CSI). To reduce file size, the DEM data were down-sampled by nearest neighbor approximation and may not match the original satellite data (Jarvis and others, 2008). One layer is included in this feature dataset solely for cartographic rendering purposes: a mask layer of the United States (as it is not part of this project's study area). The mask layer is to show the actual location of the United States in relation to the study area.

Geodatabase annotation groups—*G_ANNO* feature dataset

Geodatabase annotation groups

The *G_ANNO* feature dataset contains annotation feature classes stored in one centralized location within the geodatabase. These annotation featue classes correspond to the map labels on the geospatial PDF map and to the on-screen labels in the GIS map document (table 28). Within the geospatial PDF map document, annotation feature class layers immediately precede the layer to which they refer. They contain the word "labels" in the map layer description in the menu and contain the suffix "ANNO" to denote that they are an annotation group within the geodatabase. Layers that contain the prefix "XMark_" are a functional cartographic label used to indicate the visible layers in the upper right-hand area of the map.

Table 28. Annotation feature classes in the *G_ANNO* feature dataset and their corresponding map document feature class and corresponding geospatial PDF map layer, in alphabetical order by annotation feature class.

[Conv., conventional; RPP, recoverable proven plus probable resources; LNG, liquefied natural gas]

Annotation feature class	Geodatabase feature class	Map document layer and geospatial PDF map layer name
CITIES_ANNO	CITIES	Capitals and other cities (CITIES)
CONV_OIL_PROD_CNTRY_ANNO	OG_COUNTRY	Conventional oil, by country (OG_COUNTRY)
CONV_OIL_PROD_PP_ANNO	OG_PETRO_PROV	Conventional oil, by petroleum province (OG_PETRO_PROV)
CONV_OIL_RPP_CNTRY_ANNO	OG_COUNTRY	Conventional oil, RPP, by country (OG_COUNTRY)
CONV_OIL_RPP_PP_ANNO	OG_PETRO_PROV	Conventional oil, RPP, by petroleum province (OG_PETRO_PROV)
COUNTRY_ANNO	COUNTRY, USA	International boundaries (COUNTRY), United States (USA)
CU_PORPH_TRACTS_ANNO	CU_PORPH_TRACTS	Porphyry copper tracts (CU_PORPH_TRACTS)
EXPLORE_LAC_ANNO	EXPLORE_LAC	Mineral exploration and development sites (EXPLORE_LAC)
LNG_ANNO	LNG	Liquefied natural gas terminals (LNG)
MINFAC_BRINE_ANNO	MINFAC_LAC	Brine operations (MINFAC_BRINE)
MINFAC_MINE_ANNO	MINFAC_LAC	Mines (MINFAC_MINE)
MINFAC_PLANT_ANNO	MINFAC_LAC	Mineral processing plants (MINFAC_PLANT)
MINFAC_MINEPLANT_ANNO	MINFAC_LAC	Combined mine-processing plant operations (MINFAC_MINEPLANT)
MINFAC_OGFIELDS_ANNO	MINFAC_LAC	Oil and gas fields (MINFAC_OGFIELDS)
MINFAC_OGREFINE_ANNO	MINFAC_LAC	Oil and gas refineries and (or) petrochemical complexes (MINFAC_OGREFINE)
PETRO_PROV_ANNO	PETRO_PROV	USGS petroleum provinces (PETRO_PROV)
PORTS_LAC_ANNO	PORTS_LAC	Mineral commodity exporting ports (PORTS_LAC)
POWER_LAC_ANNO	POWER_LAC	Electric power generating facilities (POWER_LAC)
RIVERS_ANNO	RIVERS	Major rivers (RIVERS)

References Cited

[Entries marked with an asterisk (*) at the beginning of the reference indicate a reference for data included in the geodatabase, geospatial PDF map, or metadata that may not be cited within the body of the text. References not included in the main body of the text may be referring to information presented in appendix 2 (Case study 1: Iron ore mining and transportation infrastructure in Brazil's Iron Quadrangle) and appendix 3 (Case study 2: Bauxite mining and alumina production in Jamaica).]

*Agência Nacional de Energia Elétrica [Brazil; National Electrical Energy Agency], 2016, Download KMZ: Agência Nacional de Energia Elétrica web page, accessed February 6, 2017, at http://sigel.aneel.gov.br/kmz.html.

*Agência Nacional do Petróleo, Gás Natural e Biocombustíveis [Brazil; National Petroleum, Natural Gas, and Biocombustibles Agency], 2017, Dados de E&P— Dados Georreferenciados dos Blocos em Exploração e Campos de Produção [Explortion and production data—Exploration blocks and producing fields georeferenced data]: Agência Nacional do Petróleo, Gás Natural e Biocombustíveis web page, accessed April 30, 2017, at http://www.anp.gov.br/wwwanp/exploracao-e-producao-de-oleo-e-gas/gestao-de-contratos-de-e-p/dados-de-e-p.

Alcoa Inc., 2014, Alcoa to sell stake in Jamalco to Noble: Alcoa Inc. press release, October 15, accessed June 6, 2016, at http://news.alcoa.com/press-release/alcoa-sell-stake-jamalco-noble.

Almánzar, Francisco, Baker, M.S., Elias, Nurudeen, and Guzmán, Eric, 2010, Mineral facilities of Europe: U.S. Geological Survey Open-File Report 2010–1257, 1 pl., 47-p. table, accessed April 5, 2017, at https://pubs.usgs.gov/of/2010/1257.

Anderson, Charles, 2015, Conflict minerals from the Democratic Republic of the Congo—Tin processing plants, a critical part of the tin supply chain (ver. 2.0, July 31, 2015): U.S. Geological Survey Fact Sheet 2015–3022, 4 p., accessed April 5, 2017, at https://doi.org/10.3133/fs20153022.

Anderson, C.S., 2016a, Bismuth: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 36–37, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/bismuth/mcs-2016-bismu.pdf.

Anderson, C.S., 2016b, Selenium: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 148–149, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/selenium/mcs-2016-selen.pdf.

Anderson, C.S., 2016c, Tellurium: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 168–169, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/selenium/mcs-2016-tellu.pdf.

Anderson, C.S., 2016d, Tin: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 174–175, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/tin/mcs-2016-tin.pdf.

*Asociación Colombiana de Generadores de Energía Eléctrica (ACOLGEN) [Colombia], 2017, Mapa de Ubicación de Centrales—Centrales de Asociados mayors a 50 MW: Asociación Colombiana de Generadores de Energía Eléctrica web page, accessed February 6, 2017, at http://www.acolgen.org.co/index.php/2013-01-31-06-37-23/mapa-de-ubicacion.

Ausenco Ltd., 2016, Samarco iron concentrate pipelines system—Longest iron concentrate pipeline system in the world: Ausenco Ltd. case studies web page, accessed June 6, 2016, at http://www.ausenco.com/case-studies/samarco.

*Autoridad de Fiscalización y Control de Electricidad [Bolivia], 2016a, Mapa plantas de generación eléctrica Bolivia [Map of electricity-generating plants in Bolivia]: GeoBolivia web catalog, accessed February 6, 2017, at http://geo.gob.bo/geonetwork/srv/eng/catalog.search#/metadata/a298df7e-4a49-4ee4-acba-06b8347fb29e.

*Autoridad de Fiscalización y Control de Electricidad [Bolivia], 2016b, Mapa red eléctrica de alta tensión en Bolivia [Map of the high-voltage power grid in Bolivia]: GeoBolivia web catalog, accessed February 6, 2017, at http://geo.gob.bo/geonetwork/srv/eng/catalog.search#/metadata/e2e0f864-2c6e-4d04-a519-25ddd8742c72.

Baker, M.S., Bleiwas, D.I., and Goonan, T.G., 2016, Mineral commodity exporting ports of Latin America and the Caribbean: U.S. Geological Survey data release, accessed April 5, 2017, at https://doi.org/10.5066/F7BZ6460.

Baker, M.S., and Buteyn, S.D., 2016, Mineral facilities of Latin America and the Caribbean: U.S. Geological Survey data release, accessed April 5, 2017, at https://doi.org/10.5066/F7MG7MM6.

Baker, M.S., Elias, Nurudeen, Guzmán, Eric, and Soto-Viruet, Yadira, 2010a, Mineral facilities of Asia and the Pacific: U.S. Geological Survey Open-File Report 2010–1254, 1 pl., 51-p. table, accessed April 5, 2017, at https://pubs.usgs.gov/of/2010/1254.

Baker, M.S., Elias, Nurudeen, Guzmán, Eric, and Soto-Viruet, Yadira, 2010b, Mineral facilities of Northern and Central Eurasia: U.S. Geological Survey Open-File Report 2010–1255, 1 pl., 27-p. table, accessed April 5, 2017, at https://pubs.usgs.gov/of/2010/1255.

Baker, M.S., and Wilburn, D.R., 2016, Mineral exploration sites of Latin America and the Caribbean: U.S. Geological Survey data release, accessed April 5, 2017, at https://doi.org/10.5066/F7GQ6VWG.

Bank of Jamaica, 2016, Jamaica in figures, 2015: Kingston, Jamaica, Bank of Jamaica, 2. p., accessed April 5, 2017, at http://www.boj.org.jm/uploads/pdf/jam_figures/jam_figures_2015.pdf.

Bedinger, G.M., 2016, Titanium mineral concentrates (ilmenite) : U.S. Geological Survey Mineral Commodity Summaries 2015, p. 178–179, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/titanium/mcs-2016-timin.pdf.

Bermúdez-Lugo, Omayra, 2004, The mineral industries of the islands of the Caribbean, *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbook 2002, v. III, p. 12.1–12.12., 1 table, accessed April 5, 2017, at http://minerals.usgs.gov/minerals/pubs/country/2001/caribbeanmyb01r.pdf.

Bermúdez-Lugo, Omayra, 2014, Conflict minerals from the Democratic Republic of the Congo—Global tungsten processing plants, a critical part of the tungsten supply chain (ver. 1.1, August 2014): U.S. Geological Survey Fact Sheet 2014–3069, 4 p., accessed April 5, 2017, at https://doi.org/10.3133/fs20143069.

Bermúdez-Lugo, Omayra, and Menzie, W.D., 2015, The Ebola virus disease outbreak and the mineral sectors of Guinea, Liberia, and Sierra Leone: U.S. Geological Survey Fact Sheet 2015–3033, 8 p., accessed April 5, 2017, at https://doi.org/10.3133/fs20153033.

Bernstein, Rachel, Eros, Mike, and Quintana-Velazquez, Meliany, 2006, Mineral facilities of Latin America and Canada: U.S. Geological Survey Open-File Report 2006–1375, 1 pl., 47-p. table, accessed April 5, 2017, at https://pubs.usgs.gov/of/2006/1375/.

BHP Billiton Ltd., 2002, Annual report 2001, part C—Description of business: BHP Billiton Ltd., 110 p., accessed June 6, 2016, at http://www.bhpbilliton.com/~/media/bhp/documents/investors/reports/2001/2001bhpbillitonltdannualreport_partc.pdf?la=en.

Bray, E.L., 2016a, Bauxite: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 32–33, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/bauxite/mcs-2016-bauxi.pdf.

Bray, E.L., 2016b, Magnesium compounds: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 102–103, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/magnesium/mcs-2016-mgcom.pdf.

Bray, E.L., 2016c, Bauxite and alumina [advance release], *in* Metals and minerals: U.S. Geological Survey Minerals Yearbook 2014, v. I, p. 10.1–10.13, accessed March 26, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/bauxite/myb1-2014-bauxi.pdf.

Brininstool, Mark, 2016, Copper: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 54–55, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2016-coppe.pdf.

Burma, Christine, and Hong, C.H., 2014, U.S. gas boom turns global as LNG exports to shake up markets: Bloomberg News, October 1, 2014, accessed August 2016 at http://www.bloomberg.com/news/articles/2014-09-30/u-s-gas-boom-turns-global-as-lng-exports-set-to-shake-up-market.

Campbell, Keith, 2013, The state of mining in South America—an overview: Mining Weekly, June 21, 2013, accessed August 2016 at http://www.miningweekly.com/print-version/mining-and-south-america-today-2013-06-21.

*CartoCrítica, 2017, Industrias extractivas y concesiones: CartoCrítica interactive web map with data from the Comisión Nacional de Hidrocarburos of Mexico, accessed February 6, 2017, at http://www.cartocritica.org.mx/2015/industrias-extractivas/.

Cawthorne, Andrew, 2016, Drought-hit Venezuela awaits rain at crucial Guri dam: Thomson Reuters, April 13, 2016, accessed April 14, 2016, at http://www.reuters.com/article/us-venezuela-energy-idUSKCN0XA1WL.

*Cereijo, Manuel, 2010, Republic of Cuba—Power sector infrastructure assessment: Cuba Transition Project, Institute for Cuban and Cuban-American Studies, University of Miami, 79 p., accessed February 6, 2017, at https://web.archive.org/web/20121203044053/http://ctp.iccas.miami.edu/Appendices/Appendix_D_Power/Cereijo_2010a.pdf.

*CGX Energy Inc., 2016, CGX at a glance—Leasing overview map: CGX Energy Inc. web page, accessed April 2016 at http://cgxenergy.ca/At-A-Glance.aspx.

*Comisión Nacional de Energía Eléctrica [Guatemala; National Electric Energy Commission], 2017, Mapa de presas en Guatemala: Comisión Nacional de Energía Eléctrica web page, accessed February 6, 2017, at http://www.cnee.gob.gt/wp/?page_id=239.

*Comisión Nacional de Hidrocarburos [Mexico; National Hydrocarbons Commission], 2016, Portal de Información Técnica del CNIH [Technical Information Portal of the National Hydrocarbons Commission]: Comisión Nacional de Hidrocarburos interactive web map browser, accessed February 6, 2017, at http://portal.cnih.cnh.gob.mx/iicnih/.

Companhia Hispano-Brasileira de Pelotização, 2014, Companhia Hispano-Brasileira de Pelotização—HISPANOBRAS, Demonstrações financeiras em 31 de dezembro de 2013 [Financial statements as of December 31, 2013]: Rio de Janeiro, Brazil, Companhia Hispano-Brasileira de Pelotização, 25 p., accessed June 6, 2016, at http://www.vale.com/EN/investors/information-market/financial-statements/ControladasColigadasDocuments/DC_Hispanobras_2013.pdf.

Corathers, L.A., 2016, Manganese: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 106–107, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/manganese/mcs-2016-manga.pdf.

*Corporación Eléctrica del Ecuador, 2014, Sistema Nacional de Transmision (SNT)—Esquema geografico del SNT: Corporación Eléctrica del Ecuador web page, accessed February 6, 2017, at https://www.celec.gob.ec/transelectric/images/stories/baners_home/Plan%20expansion/mapa%20snt%20a%20diciembre%202013.pdf.

*Corporación Eléctrica Nacional S.A. (CORPOLEC) [Venezuela], 2017, Transmision: Corporación Eléctrica Nacional S.A. web page, accessed February 6, 2017, at http://www.corpoelec.gob.ve/transmisi%C3%B3n.

Crangle, R.D., Jr., 2016, Boron: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 38–39, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/boron/mcs-2016-boron.pdf.

Cunningham, C.G., Zappettini, E.O., Vivallo S., Waldo, Celada, C.M., Quispe, Jorge, Singer, D.A., Briskey, J.A, Sutphin, D.M., Gajardo M., Mariano, Diaz, Alejandro, Portigliati, Carlos, Berger, V.I., Carrasco, Rodrigo, and Schulz, K.J., 2008, Quantitative mineral resource assessment of copper, molybdenum, gold, and silver in undiscovered porphyry copper deposits in the Andes Mountains of South America: U.S. Geological Survey Open-File Report 2008-1253, 282 p., 1 CD-ROM, accessed April 5, 2017, at https://pubs.usgs.gov/of/2008/1253/.

*Daily Ambito Financiero, 2015, Senado convirtío en ley estatización de trenes: Daily Ambito Financiero [Buenos Aires, Argentina], April 15, 2015, accessed March 2016 at http://www.ambito.com/786700-senado-convirtio-en-ley-estatizacion-de-trenes.

*Departamento Nacional de Produção Mineral [Brazil; National Department of Mineral Production], 2016, Sumário mineral 2015—Produção Mineral Brasileira [Mineral summary 2015—Brazilian mineral production]: Departamento Nacional de Produção Mineral, April 5, 2016, accessed June 6, 2016, at http://www.dnpm.gov.br/dnpm/colecoes/colecao-de-sumarios-sumario-mineral.

*Dicken, C.L., Dunlap, Pamela, Parks, H.L., Hammarstrom, J.M., and Zientek, M.L., 2016, Spatial database for a global assessment of undiscovered copper resources: U.S. Geological Survey Scientific Investigations Report 2010–5090–Z, 29 p., and GIS data, accessed August 2016 at https://doi.org/10.3133/sir20105090Z.

Dixon, A.P., and Nakagawa, Masami, 2016, Geothermal energy for mining in Chile—Current situation and opportunities: Proceedings of the 41st workshop on geothermal reservoir engineering, Stanford University, February 22–24, 2016, accessed April 24, 2017, at https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2016/Dixon.pdf.

Dorr, J.V.N., and Barbosa, A.L. de M., 1963, Geology and Ore Deposits of the Itabira District, Minas Gerais, Brazil, U.S. Geological Survey Professional Paper 341–C, accessed June 6, 2016, at https://pubs.er.usgs.gov/publications/pp341C.

Economic Commission for Latin America and the Caribbean, 2016, Foreign direct investment towards the region fell 9.1% in 2015 to total $179.10 billion dollars: Economic Commission for Latin America and the Caribbean press release, June 15, 2016, accessed September 2016 at http://www.cepal.org/en/pressreleases/foreign-direct-investment-towards-region-fell-91-2015-total-17910-billion-dollars.

Economic Commission for Latin America and the Caribbean, 2017, Latin America and the Caribbean—regional economic profile, data statistics and indicators: Economic Commission for Latin America and the Caribbean web page, accessed March 8, 2017, at http://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/estadisticasIndicadores.asp?idioma=i.

*Economic Consulting Associates Ltd., 2010, The potential of regional power sector integration—Central American Electric Interconnection System (SIEPAC) transmission and trading case study: Economic Consulting Associates Ltd., March 2010, accessed June 2016 at http://www.esmap.org/sites/esmap.org/files/BN004-10_REISP-CD_Central%20American%20Electric%20Interconnection%20System-Transmisison%20&%20Trading.pdf.

*Economist, The, 2005, Energy in the southern cone—Gas ring: The Economist (map content reproduced with permission), August 18, 2005, accessed June 21, 2016, at http://www.economist.com/node/4301018.

*Ecopetrol S.A., 2011, Form 20–F for the fiscal year ended December 31, 2010: U.S. Securities and Exchange Commission, July 25, 2011, accessed June 2016 at http://www.sec.gov/Archives/edgar/data/1444406/000114420411040868/v228285_20f.htm.

*Energy and Climate Partnership of the Americas, 2016, Advanced power sector integration and cross border trade in electricity—Central America and SIEPAC: Energy and Climate Partnership of the Americas web page, accessed June 2016 at http://www.ecpamericas.org/initiatives/?id=70.

*Ente Nacional Regulador de la Electricidad [Argentina; National Electricity Regulatory Body], 1999, Informe annual 1999 [Annual report 1999]: Ente Nacional Regulador de la Electricidad, 301 p., accessed August 2016 at http://www.enre.gov.ar/web/web.nsf/Files/informe1999.pdf/$FILE/informe1999.pdf.

Eros, J.M., and Candelario-Quintana, Luissette, 2006, Mineral facilities of Africa and the Middle East: U.S. Geological Survey Open-File Report 2006–1135, 1 pl., 1 table, accessed April 5, 2017, at https://pubs.usgs.gov/of/2006/1135/.

*Esri, 2012, Bolivian pipeline company expands into mobile asset management: Esri news release, Fall 2012, accessed October 2016 at http://www.esri.com/news/arcnews/fall12articles/bolivian-pipeline-company-expands-into-mobile-asset-management.html.

*Esri, 2017a, World cities—Esri data and maps: ArcGIS Online data layer package, April 21, accessed April 24, 2017, at http://www.arcgis.com/home/item.html?id=dfab3b294ab24961899b2a98e9e8cd3d [modified by author to include regional data not included in this base map layer].

*Esri, 2017b, World major rivers—Esri data and maps: ArcGIS Online data layer package, January 17, accessed April 24, 2017, at http://www.arcgis.com/home/item.html?id=44e8358cf83a4b43bc863646cd695945 [modified by author to include regional data not included in this base map layer, including a river course correction to the Paraguay River].

Flavin, Christopher, Gonzalez, Milena, Majano, A.M., Ochs, Alexander, Rocha Oliveira, M.G. da, and Tagwerker, Philipp, 2014, Study on the devleopment of the renewable energy market in Latin America and the Caribbean: Inter-American Development Bank, Office of Evaluation and Oversight, working paper IDB RFP #14–002, November, accessed August 2016 at https://publications.iadb.org/bitstream/handle/11319/6711/Study-on-the-Development-of-the-Renewable-Energy-Market-in-Latin-America-and-the-Caribbean.pdf.

Fortier, S.M., DeYoung, J.H., Jr., Sangine, E.S., and Schnebele, E.K., 2015, Comparison of U.S. net import reliance for nonfuel mineral commodities—A 60-year retrospective (1954–1984–2014): U.S. Geological Survey Fact Sheet 2015–3082, 4 p., accessed April 5, 2017, at https://doi.org/10.3133/fs20153082.

*French, C.D., and Schenk, C.J., comps., 2004, Map showing geology, oil and gas fields, and geologic provinces of the Caribbean region: U.S. Geological Survey Open-File Report 97–470–K, accessed September 2016 at https://pubs.usgs.gov/of/1997/ofr-97-470/OF97-470K.

Gambogi, J., 2016, Rare earths: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 134–135, accessed April 5, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2016-raree.pdf.

*Gasoducto Cruz del Sur S.A., 2017, Gasoducto—Trazado: Gasoducto Cruz del Sur S.A. web page, accessed March 15, 2017, at http://www.gasoductocruzdelsur.com.uy/gas_trazados.php.

George, M.W., 2015, Conflict minerals from the Democratic Republic of the Congo—Gold supply chain (ver. 1.1, December 10, 2015): U.S. Geological Survey Fact Sheet 2015–3075, 4 p., accessed April 5, 2017, at https://doi.org/10.3133/fs20153075.

George, M.W., 2016a, Gold: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 72–73, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/gold/mcs-2016-gold.pdf.

George, M.W., 2016b, Silver: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 152–153, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/silver/mcs-2016-silve.pdf.

Gleaner, The, 2014, RUSAL acquires remaining government stake in WINDALCO: The Gleaner [Kingston, Jamaica], December 12, 2014, accessed June 2016 at http://jamaica-gleaner.com/article/news/20141212/rusal-acquires-remaining-government-stake-windalco.

Gleaner, The, 2016, Alpart sold for US $300m—UC RUSAL seals deal with JISCO in Beijing: The Gleaner [Kingston, Jamaica], July 20, 2016, accessed April 5, 2017, at http://jamaica-gleaner.com/article/business/20160720/alpart-sold-us300m-uc-rusal-seals-deal-jisco-beijing.

*Gray, F., Hammarstrom, J.M., Ludington, S., Zürcher, L., Nelson, C.E., Robinson, G.R., Jr., Miller, R.J., and Moring, B.C., 2014, Porphyry copper assessment of Central America and the Caribbean Basin: U.S. Geological Survey Scientific Investigations Report 2010–5090–I, 81 p., and GIS data, accessed August 2016 at https://doi.org/10.3133/sir20105090I.

Guberman, D.E., 2016a, Antimony: U.S. Geological Survey Mineral Commodity Summaries 2016, p. 24–25, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/antimony/mcs-2016-antim.pdf.

Guberman, D.E., 2016b, Lead: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 96–97, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/lead/mcs-2016-lead.pdf.

*Hammarstrom, J.M., Robinson, G.R., Jr., Ludington, Steve, Gray, Floyd, Drenth, B.J., Cendejas-Cruz, Francisco, Espinosa, Enrique, Pérez-Segura, Efrén, Valencia-Moreno, Martín, Rodríguez-Castañeda, José Luis, Vásquez-Mendoza, Rigoberto, and Zürcher, Lukas, 2010, Porphyry copper assessment of Mexico: U.S. Geological Survey Scientific Investigations Report 2010–5090–A, 176 p., accessed October 2016 at https://pubs.usgs.gov/sir/2010/5090/a/.

Hastorun, Sinan, Renaud, K.M., and Lederer, G.W., 2016, Recent trends in the nonfuel minerals industry of Iran: U.S. Geological Survey Circular 1421, 18 p., accessed April 24, 2017, at https://doi.org/10.3133/cir1421.

*ICR News, 2013, Tensions between Costa Rica and Nicaragua over oil concessions could lead to conflict: ICR News, July 23, 2013, accessed August 2016 at http://inside-costarica.com/2013/07/23/tensions-between-costa-rica-and-nicaragua-over-oil-concessions-could-lead-to-conflict/.

IHS Global Inc., 2016, International exploration and production database: IHS Global database, accessed May 2, 2016, at https://www.ihs.com/pdf/International-Exploration-Production-Database-IHS_165378110913044932.pdf. [Note: database is a subscription service not available via the web. Link is to an informational brochure.]

*Instituto Costarricense de Electricidad, 2006, Sistema de Transmisión Centraamericana—Año 2006 [Central American Transmission System—2006]: Instituto Costarricense de Electricidad, accessed July 2016 at http://www.geni.org/globalenergy/library/national_energy_grid/central-american-grid/graphics/centralamericagrid.gif.

*Instituto Nacional de Estadística y Geografía [Mexico; National Institute of Statistics and Geography], 2017, Datos vectoriales escala 1:1000000—descarga, Generación, transmisión, de energía, y conductos (conducto, línea transmisión, planta generadora): Instituto Nacional de Estadística y Geografía, accessed February 6, 2017, at http://www.inegi.org.mx/geo/contenidos/topografia/topografia_1m.aspx.

*International Council of Large Energy Systems (CIGRE), 2016, The electric power system—Chile: International Council of Large Energy Systems presentation, accessed August 2016 at http://www.cigre.org/var/cigre/storage/original/application/6a789c1375a22a39e14a284bee7ff988.pdf.

International Gas Union, 2016, 2016 world LNG report: International Gas Union, 88 p., accessed October 2016 at http://www.igu.org/publications/2016-world-lng-report.

International Hydropower Association, 2016, Brazil—Hydropower overview: International Hydropower Association web page, accessed August 2016 at https://www.hydropower.org/country-profiles/brazil.

*Itaipu Binacional, 2016, Integraçao ao Sistema paraguano [Integration with the Paraguayan system]: Itaipu Binacional web page, accessed March 2017 at https://www.itaipu.gov.br/energia/integracao-ao-sistema-paraguaio.

Jamaica Bauxite Institute, 2015a, Alumina & bauxite plants and ports: Jamaica Bauxite Institute web page, accessed June 2016 at http://www.jbi.org.jm/.

Jamaica Bauxite Institute, 2015b, Bauxite and alumina plants: Jamaica Bauxite Institute web page, accessed June 2016 at http://www.jbi.org.jm/pages/bauxite_alumina_plants.

Jamaica Bauxite Institute, 2015c, Government involvement: Jamaica Bauxite Institute web page, accessed June 2016 at http://www.jbi.org.jm/pages/government_involvement.

Jamaica Bauxite Institute, 2015d, The making of an industry: Jamaica Bauxite Institute web page, accessed June 2016 at http://www.jbi.org.jm/pages/bauxite_alumina_plants.

Jamalco Inc., 2014, About us—Who we are: Jamalco Inc. web page, accessed June 2016 at http://www.jamalco.com/jamalco/about-us.html.

*Jarvis, A., Reuter, H.I., Nelson, A., and Guevara, E., 2008, Hole-filled SRTM for the globe, Version 4: International Centre for Tropical Agriculture CGIAR-CSI SRTM 90m database, accessed October 26, 2016, at http://srtm.csi.cgiar.org.

Jasinski, S.M., 2016a, Phosphate rock: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 124–125, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/mcs-2016-phosp.pdf.

Jasinski, S.M., 2016b, Potash: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 128–129, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/potash/mcs-2016-potas.pdf.

Jaskula, B.W., 2016, Lithium: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 100–101, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/lithium/mcs-2016-lithi.pdf.

*Johnson, K.M., Hammarstrom, J.M., Zientek, M.L., and Dicken, C.L., 2014, Estimate of undiscovered copper resources of the world, 2013: U.S. Geological Survey Fact Sheet 2014–3004, 3 p., accessed August 2016 at https://doi.org/10.3133/fs20143004.

*Kashi, David, 2013, Colombia warns Nicaragua not to explore for oil in Caribbean waters claimed by Colombia: International Business Times, August 2, 2013, accessed February 6, 2017, at http://www.ibtimes.com/colombia-warns-nicaragua-not-explore-oil-caribbean-waters-claimed-colombia-1370589.

*Klett, T.R., Ahlbrandt, T.S., Schmoker, J.W., and Dalton, G.L., 1997, Ranking of the world's known oil and gas provinces by known petroleum volumes: USGS Open-File Report 97–463, accessed February 1, 2016, at https://pubs.usgs.gov/of/1997/ofr-97-463/97463.html.

Kuck, P.H., 2016, Nickel: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 114–115, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/nickel/mcs-2016-nicke.pdf.

Lederer, G.W., 2016, Resource nationalism in Indonesia—Effects of the 2014 mineral export ban: U.S. Geological Survey Fact Sheet 2016–3072, 6 p., accessed April 24, 2017, at https://doi.org/10.3133/fs20163072.

McCrae, M.A., 2016, Why Samarco tailings dam failed: MINING.com, August 29, 2016, accessed October 2016 at http://www.mining.com/why-samarco-tailings-dam-failed/.

McIntyre, A., El-Ashram, A., Ronci, M., Reynaud, J., Che, N., Wang., K., Acevedo, S., Lutz, M., Strodel, F., Osueke, A., and Yun, H., 2016, Caribbean energy—Macro-related challenges: International Monetary Fund Working Paper WP/16/53, March, accessed April 24, 2017, at https://www.imf.org/external/pubs/ft/wp/2016/wp1653.pdf.

McRae, M.E., 2016a, Barite: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 30–31, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/barite/mcs-2016-barit.pdf.

McRae, M.E., 2016b, Fluorspar: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 62–63, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/fluorspar/mcs-2016-fluor.pdf.

*Ministerio de Electricidad y Energía Renovable [Ecuador; Ministry of Electricity and Renewable Energy], 2016, Sistema de transmission de extra alta tension de 500 MIL voltios [Extra high voltage transmission system—500,000 volts]: Ministerio de Electricidad y Energía Renovable web page, accessed February 9, 2017, at https://www.celec.gob.ec/transelectric/index.php?option=com_content&view=article&id=481&Itemid=534&lang=es.

*Ministerio de Energía, Infraestructura de Datos Especiales [Chile], 2017, Infraestructura Asociada a Combustible (Gasoductos y oleoductos), Centrales Generación Eléctrica (Eólicas, hidroeléctrica, solares, termoeléctricas), Sistema de Transmisión Eléctrica (Linea de Transmisión SING, Linea de Transmisión SIC, Linea de Transmisión Aysen): Ministerio de Energía, Infraestructura de Datos Especiales interactive map, accessed February 6, 2017, at http://sig.minenergia.cl/sig-minen/moduloCartografico/composer/.

*Ministerio de Energía y Minas, Dirección General de Hidrocarburos [Guatemala], 2007, Exploración y explotación petrolera en Guatemala: Ministerio de Energía y Minas web page and presentation, accessed February 6, 2017, at http://www.mem.gob.gt/wp-content/uploads/2012/05/1.-A%C3%B1o-2007-Numero-1-Historia.pdf.

*Ministerio de Energía y Minas [Dominican Republic], 2015, Discovering the hydrocarbon potential of the Dominican Republic: Ministerio de Energía y Minas, 16 p., accessed February 6, 2017, at http://www.mem.gob.do/images/docs/ExecutiveSummaryDRModeling.pdf.

*Ministerio de Energía y Minas [Nicaragua; Ministry of Energy and Mines], 2008, Areas disponibles para exploracion y explotacion de hidrocarburos en Nicaragua [Map of available areas for hydrocarbon exploration and exploitation in Nicaragua]: Ministerio de Energía y Minas, September 2008, accessed June 18, 2016, at http://insidecostarica.com/wp-content/uploads/2013/07/mapa-petroleo.png.

*Ministerio de Energía y Minas [Peru], 2005, Principales centrales eléctricas 2005: Ministerio de Energía y Minas, 1 p., accessed February 6, 2017, at http://web.archive.org/web/20090620063719/http://www.minem.gob.pe/archivos/dge/mapas/centraleselctricas.pdf.

*Ministerio de Energía y Minas [Peru], 2011, Líneas de Transmisión Eléctrica 2011 [Electric transmission lines 2011]: Ministerio de Energía y Minas, accessed February 9, 2017, at http://www.minem.gob.pe/_publicacion.php?idSector=6&idPublicacion=395.

*Ministerio de Energía y Minería [Argentina], 2017a, Generación eléctrica—Centrales de generación: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/generacion-electrica-centrales-de-generacion-.

*Ministerio de Energía y Minería [Argentina], 2017b, Producción hidrocarburos—Concesiones de explotación: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/produccion-hidrocarburos-concesiones-de-explotacion.

*Ministerio de Energía y Minería [Argentina], 2017c, Producción hidrocarburos—Lotes de explotación: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/produccion-hidrocarburos-lotes-de-explotacion.

*Ministerio de Energía y Minería [Argentina], 2017d, Producción hidrocarburos—Permisos de exploración: Ministerio de Energía y Minería web page, accessed March 14, 2017, at http://datos.minem.gob.ar/exploracion-hidrocarburos-permisos-de-exploracion.

*Ministerio de Energía y Minería [Argentina], 2017e, Transporte eléctrico—AT Líneas: Ministerio de Energía y Minería Presidencia de la Nación web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-electrico-at-lineas-.

*Ministerio de Energía y Minería [Argentina], 2017f, Transporte hidrocarburos—Ductos troncales—Gasoductos: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-hidrocarburos-ductos-troncales-gasoductos.

*Ministerio de Energía y Minería [Argentina], 2017g, Transporte hidrocarburos—Ductos troncales—Oleoductos: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-hidrocarburos-ductos-troncales-oleoductos.

*Ministerio de Energía y Minería [Argentina], 2017h, Transporte hidrocarburos—Ductos troncales—JP Ducto: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-hidrocarburos-ductos-troncales-jp-ducto.

*Ministerio de Energía y Minería [Argentina], 2017i, Transporte hidrocarburos—Ductos troncales—Poliductos: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-hidrocarburos-ductos-troncales-poliductos.

*Ministerio de Energía y Minería [Argentina], 2017j, Transporte hidrocarburos—Ductos troncales—Propanoductos: Ministerio de Energía y Minería web page, accessed February 6, 2017, at http://datos.minem.gob.ar/transporte-hidrocarburos-ductos-troncales-propanoductos.

*Ministerio Hidrocarburos y Energía [Bolivia; Ministry of Hydrocarbons and Energy], 2005, Bloques, campos, sistemas de conducción de hidrocarburos [Blocks, fields, and hydrocarbon driving systems]: Ministerio Hidrocarburoas y Energía web page, accessed February 6, 2017, at http://www2.hidrocarburos.gob.bo/.

*Ministerio de Industria, Energía, y Minería [Uruguay], 2016a, Listado de autorizaciones de generación en el marco del Decreto No360-2002: Ministerio de Industria, Energía y Minería web page, accessed February 6, 2017, at http://www.dne.gub.uy/web/energia/-/listado-de-autorizaciones-de-generacion-en-el-marco-del-decreto-n%C2%B0360-2002.

* Ministerio de Industria, Energía, y Minería [Uruguay], 2016b, Mapas energéticos—Actualización octubre 2016: Ministerio de Industria, Energía, y Minería web map, accessed March 16, 2017, at http://www.miem.gub.uy/web/energia/publicaciones-y-estadisticas/planificacion-y-balance/-/asset_publisher/mf9rbTfIofs2/content/mapas-energeticos-actualizacion-octubre-2016;jsessionid=064B9FCA65E79C023C11521EDB75C6A3?redirect=http%3A%2F%2Fwww.miem.gub.uy%2Fweb%2Fenergia%2Fpublicaciones-y-estadisticas%2Fplanificacion-y-balance%3Bjsessionid%3D064B9FCA65E79C023C11521EDB75C6A3%3Fp_p_id%3D101_INSTANCE_mf9rbTfIofs2%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-1%26p_p_col_count%3D1.

*Ministerio de Industria, Energía, y Minería [Uruguay], 2016c, Mapa petrolero: Administración Nacional de Combustibles, Alcoholes y Portland, Exploración y Producción de Hidrocarburos, Ministerio de Industria, Energía, y Minería web map, accessed February 6, 2017, at http://exploracionyproduccion.ancap.com.uy/.

*Ministerio de Obras Publicas y Comunicaciones, Viceministerio de Minas y Energia [Paraguay], 2016, Catasto hidrocarburos—MAPA: Ministerio de Obras Publicas y Comunicaciones, November 1, 2016, accessed February 6, 2017, at http://www.ssme.gov.py/vmme/images/CatastroHidrocarburo/hidrocar_1-11-2016.png.

*Ministerio de Obras Públicas y Comunicaciones, Viceministerio de Minas y Energía [Paraguay], 2017, Electricidad—Generación: Ministerio de Obras Públicas y Comunicaciones, Viceministerio de Minas y Energía web page, accessed February 6, 2017, at http://www.ssme.gov.py/vmme/index.php?option=com_content&view=article&id=1216&.

*Ministry of Energy, Science and Technology, and Public Utilities [Belize], 2015, Belize petroleum contracts map: Ministry of Energy, Science and Technology, and Public Utilities, December 2015, accessed February 6, 2017, at http://estpu.gov.bz/index.php/geology-petroleum/gpd-petroleum-maps.

MMX Mineração e Metálicos S.A, [undated], Histórico e perfil corporativo [History and corporate profile]: MMX Mineração e Metálicos S.A., accessed June 2016 at http://www.mmx.com.br/show.aspx?idCanal=WN8uWmElUNSP1Zd5BsG5aQ==.

*Mobbs, P.M., 2015, The mineral industry of Guyana [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 12.1–12.3, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-gy.pdf.

*Mobbs, P.M., 2016a, The mineral industry of French Guiana [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p.11.1–11.2, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-fg.pdf.

*Mobbs, P.M., 2016b, The mineral industry of Suriname [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 16.1–16.4, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-ns.pdf.

Myers, Garfield, 2015, Alpart begins bauxite export from Port Kaiser: Jamaica Observer, September 9, accessed June 2016 at http://www.jamaicaobserver.com/news/Paulwell-hails-resumption-of-bauxite-export-from-Alpart_19227791.

*National Geospatial-Intelligence Agency (formerly U.S. National Imagery and Mapping Agency), 1992, Digital chart of the world [data as of March 2016]: National Geospatial-Intelligence Agency dataset, accessed March 2016 at http://earth-info.nga.mil/publications/vmap0.html.

*National Geospatial-Intelligence Agency, 2017, Geopolitical Entities, Names, and Codes Standard: National Geospatial-Intelligence Agency dataset, accessed April 9, 2017, at https://nsgreg.nga.mil/genc/discovery.

*National Geospatial-Intelligence Agency, Maritime Safety Office, 2013, World port index (22d ed.): National Geospatial-Intelligence Agency, Publication 150, accessed October 31, 2013, at http://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/WPI/Pub150bk.pdf. [Note: URL is only available for the most current version, the 26th edition as of 2017.]

Noble Group Ltd., 2016, Annual report 2015: Noble Group Ltd., 208 p., accessed June 2016 at http://www.thisisnoble.com/images/investors/financialInformation/annualReport/ar2015.pdf.

Noranda Aluminum Holding Corp., 2015, 2014 annual report: Noranda Aluminum Holding Corp., 122 p., accessed June 2016 at http://media.corporate-ir.net/media_files/IROL/22/220051/AR/Noranda_AR14.pdf.

*Offshore Post, 2015, Ecopetrol discovers hydrocarbons offshore Colombia: Offshore Post, August 1, 2015, accessed August 2016 at http://www.offshorepost.com/ecopetrol-discovers-hydrocarbons-offshore-colombia/.

Oil and Gas Year Ltd., The, 2015, 10 years of Camisea—The natural gas revolution in Peru: The Oil and Gas Year Ltd., February 24, 2015, accessed October 2016 at http://www.theoilandgasyear.com/articles/10-years-of-camisea-the-natural-gas-revolution-in-peru/.

Olson, D.W., 2016, Graphite (natural): U.S. Geological Survey Mineral Commodity Summaries 2016, p. 74–75, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/graphite/mcs-2016-graph.pdf.

*Organismo Supervisor de la Inversión en Energía y Minería [Peru], 2016, Centrales de Generación Eléctrica—En operación: Organismo Supervisor de la Inversion en Energia y Mineria, October 2016, accessed February 6, 2017, at http://www.osinergmin.gob.pe/seccion/centro_documental/electricidad/Documentos/PROYECTOS%20GFE/Generaci%C3%B3n/2-EN-OPERACION.pdf.

Papp, J.F., 2014, Conflict minerals from the Democratic Republic of the Congo—Global tantalum processing plants, a critical part of the tantalum supply chain: U.S. Geological Survey Fact Sheet 2014–3122, 4 p., accessed April 24, 2017, at https://doi.org/10.3133/fs20143122.

Papp, J.F., 2016a, Niobium (columbium): U.S. Geological Survey Mineral Commodity Summaries 2015, p. 116–117, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/niobium/mcs-2016-niobi.pdf.

Papp, J.F., 2016b, Tantalum: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 166–167, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/niobium/mcs-2016-tanta.pdf.

Patterson, S.H., Kurtz, H.F., Olson, J.C., and Neeley, C.L., 1986, World bauxite resources, chap. B *of* Geology and resources of aluminum: U.S. Geological Survey Professional Paper 1076–B, p. B1–B151, accessed June 6, 2016, at https://pubs.er.usgs.gov/publication/pp1076B.

*Perez, A.A., 2016, The mineral industry of Mexico [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 14.1–14.11, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-mx.pdf.

*PeruPetro S.A., 2016, Block maps: PeruPetro S.A. web page, accessed June 18, 2016, at http://www.perupetro.com.pe/wps/wcm/connect/perupetro/site-en/ImportantInformation/Block%20Maps/Block%20Maps.

*Petróleos Mexicanos, 2011, Form 20–F for the fiscal year ended December 31, 2010: U.S. Securities and Exchange Commission, June 30, 2011, accessed October 2016 at https://www.sec.gov/Archives/edgar/data/932782/000119312511178804/d20f.htm.

*Petroleum Economist, 2015, Energy map of Trinidad and Tobago, 2015 edition: The National Gas Company of Trinidad and Tobago Ltd. web page, accessed August 2016 at http://ngc.co.tt/wp-content/uploads/pdf/publications/energy-map-of-tnt-2015-ed.pdf.

Piñón, J.R., 2007, Cuba's future energy challenge [abs.]: Law of the Sea Institute Conference, Corpus Christi, Texas, March 22–24, 2007, accessed February 2015 at http://losi.tamucc.edu/Panels/Panelist%20Abstracts/Abstract%20-%20Jorge%20Pinon.pdf.

Polyak, D.E., 2016a, Molybdenum: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 112–113, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/molybdenum/mcs-2016-molyb.pdf.

Polyak, D.E., 2016b, Rhenium: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 136–137, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/rhenium/mcs-2016-rheni.pdf.

Porto Sudeste do Brasil S.A., 2016, Porto Sudeste Terminal, Porto Sudeste do Brasil S.A. web site, accessed June 2016 at http://www.portosudeste.com/.

Queiroz Galvão, 2016, Santos Basin: Queiroz Galvão web page, accessed August 2016 at http://www.qgep.com.br/static/enu/bacia-de-santos.asp?idioma=enu.

Rede Ferroviária Federal, S.A., 2007, Inventariança de extinta Rede Ferroviária Federal, S.A. – RFFSA [Inventory of the defunct Federal Railway Network S.A.]: Rede Ferroviária Federal, S.A. web page, accessed August 2016 at http://www.rffsa.gov.br/.

*Rodriguez, M.R. (PETROBRAS), and S.B. Suslick (UNICAMP), 2009, An overview of Brazilian petroleum exploration lease auctions: Terrae, v. 6, no. 1, p. 6–20, accessed August 2016 at https://www.ige.unicamp.br/terrae/V6/PDF-N6/T-a1i.pdf.

*Rosales, M.A.Á., 2015, Mexican energy reform transforms markets: Transmission and Distribution World, February 24, 2015, accessed August 2016 at http://tdworld.com/renewables/mexican-energy-reform-transforms-markets-0.

*Salazar, Gabriel, and Rudnick, Hugh, 2008, Hydro power plants in Ecuador: A technical and economical analysis, *in* Conversion and delivery of electrical energy in the 21st century—Institute of Electrical and Electronics Engineers Power and Energy Society General Meeting, Pittsburgh, Pa., July 20–24, 2008: IEEE Xplore, p. 439–443, accessed February 6, 2017, at http://ieeexplore.ieee.org/abstract/document/4596897/?section=abstract.

Samarco Mineração S.A., 2016, About Samarco: Samarco Mineração S.A., accessed June 2016 at http://www.samarco.com/en/institucional/a-empresa/.

*Schenk, C.J., Viger, R.J., and Anderson, C.P., comps., 1997, Maps showing geology, oil and gas fields, and geological provinces of the South America region: U.S. Geological Survey Open-File Report 97–470D, accessed June 14, 2016, at http://pubs.usgs.gov/of/1997/ofr-97-470/OF97-470D/sam06Gmap.html.

Schnebele, E.K., 2016, Iodine: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 82–83, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/iodine/mcs-2016-iodin.pdf.

*Secretaría de Hidrocarburos [Ecuador; Secretariat of Hydrocarbons], 2016, Mapa de bloques petroleros [Map of oil blocks] Secretaría de Hidrocarburos web page, accessed June 18, 2016, at http://www.she.gob.ec/mapa-de-bloques-petroleros/.

Seth, Shobhit, 2016, South American economies reel from low Chinese demand: Investopedia, February 25, 2016, accessed August 2016 at http://www.investopedia.com/articles/investing/022516/south-american-economies-reel-low-chinese-demand.asp.

Shedd, K.B., 2016, Cobalt: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 52–53, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/cobalt/mcs-2016-cobal.pdf.

*Sipse, 2013, Escasa infraestructura encarece combustibles [Poor infrastructure makes fuel expensive]: Sipse, January 25, 2013, accessed October 2016 at http://sipse.com/mexico/escasa-infraestructura-encarece-combustibles-12185.html.

Sistema de Información Ambiental de Colombia (SIAC) [Colombia], 2017, Catálogo de mapas—Ductos S. Hidrocarburos, original data from Autoridad Nacional de Licencias Ambientales (ANLA): Sistema de Información Ambiental de Colombia Web page, accessed March 15, 2017, available at http://www.siac.gov.co/Catalogo_mapas.html.

Society of Petroleum Engineers, 2001, Guidelines for the evaluation of petroleum reserves and resources—A supplement to the SPE/WPC petroleum reserves definitions and the SPE/WPC/AAPG petroleum resources definitions: Society of Petroleum Engineers, accessed April 4, 2017, at http://www.spe.org/industry/docs/GuidelinesEvaluationReservesResources_2001.pdf.

Soto-Viruet, Yadira, 2015a, The mineral industries of the Islands of the Caribbean (Aruba, Dominican Republic, Jamaica, Trinidad and Tobago, and other islands) [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 13.1–13.9, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-aa-bf-bb-dr-jm-td.pdf.

*Soto-Viruet, Yadira, 2015b, The mineral industry of Peru [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 16.1–16.14, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-pe.pdf.

*Soto-Viruet, Yadira, 2016a, The mineral industry of Brazil [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 4.1–4.19, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-br.pdf.

*Soto-Viruet, Yadira, 2016b, The mineral industry of Cuba [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2014, v. III, p. 8.1–8.6, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2014/myb3-2014-cu.pdf.

*Soto-Viruet, Yadira, 2016c, The mineral industry of Paraguay and Uruguay [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2014, v. III, p. 14.1–14.6, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2014/myb3-2014-pa-uy.pdf.

*Soto-Viruet, Yadira, 2016d, The mineral industry of Venezuela [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 18.1–18.9, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-ve.pdf.

*Staatsolie Maatschappij Suriname N.V., 2017, About us—Company history: Staatsolie Maatschappij Suriname N.V. web page, accessed February 6, 2017, at http://www.staatsolie.com/en/about-us/history/.

*Statoil ASA, 2016, Statoil strengthens its position in Uruguay: Statoil ASA web page, February 15, 2016, accessed March 2016 at https://www.statoil.com/en/news/strengthens-position-uruguay.html.

Tewalt, S.J., Kinney, S.A., and Merrill, M.D., 2008, GIS representation of coal-bearing areas in North, Central, and South America: U.S. Geological Survey Open-File Report 2008-1257, accessed November 30, 2016, at https://pubs.usgs.gov/of/2008/1257/.

*Tirado, Sergio, 2009, Características de los sistemas eléctricos venezolanos de generación y distribución de energía eléctrica [Characteristics of Venezuelan electric power generation and distribution systems]: Departamento de Electricidad [Venezuela], Sistemas de Potencia monograph, June 2009, accessed February 6, 2017, at http://www.monografias.com/trabajos73/sistemas-electronicos-venezolanos-energia-electrica/sistemas-electronicos-venezolanos-energia-electrica2.shtml.

Tolcin, A.C., 2016, Zinc: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 192–193, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/zinc/mcs-2016-zinc.pdf.

Tuck, C.A., 2016, Iron ore: U.S. Geological Survey Mineral Commodity Summaries 2015, p. 90–91, accessed April 24, 2017, at https://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/mcs-2016-feore.pdf.

*Tullow Oil plc, 2016, New ventures—Jamaica, Jamaica map: Tullow Oil plc web page, accessed February 6, 2017, at via http://www.tullowoil.com/operations/new-ventures/jamaica.

*Unidad de Planeacion Minero Energetica and Agencia Nacional de Hidrocarburos [Colombia], 2015, Mapa de tierras ANH—2015–12–23: Agencia Nacional de Hidrocarburos dataset, accessed February 6, 2017, at http://data.guaviare.info/dataset/anh_2015_tierras_12_23 and http://upmeonline.maps.arcgis.com/apps/PublicInformation/index.html?appid=d3f4deb3cd404e8ea3f7f1e34b97b223.

*Unidad de Planeacion Minero Energetica [Colombia], 2015, Sistema de transmisión nacional actual: Unidad de Planceación Minero Energética, 1 p., accessed February 6, 2017, at http://sig.simec.gov.co/GeoPortal/images/pdf/UPME_EN_TRANSMISI%C3%93N%20PLAN%202015-%202029%20%20ACTUAL%202015.pdf.

*Unidad de Planeación Minero Energética [Colombia; Energy and Mining Planning Unit], 2010, Plan de expansión de referencia, generación – transmissión 2010–2024 [Reference expansion plan, generation-transmission 2010–2024]: Unidad de Planeación Minero Energética, 299 p., accessed February 6, 2017, at http://www.upme.gov.co/Docs/Plan_Expansion/2010/Plan_Expansion_2010-2024_Definitivo.pdf.

United Company RUSAL plc, 2015, Annual report 2014—Taming the challenge: United Company RUSAL plc, 278 p., accessed June 6, 2016, at http://www.rusal.ru/upload/iblock/f9c/Rusal_AR_2014_Eng.pdf.

United Company RUSAL plc, 2016, Annual report 2015—Driven by green power: United Company RUSAL plc, 270 p., accessed June 6, 2016, at http://www.rusal.ru/upload/iblock/a77/3600065-t01fnar%20(e-03.13).pdf.

*United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Regional Office for Latin America (ROLA) and Instituto Geográfico Nacional [Peru], 2015, Industria de Peru: Humanitarian Data Exchange dataset, July 24, 2015, accessed February 6, 2017, at https://data.humdata.org/dataset/industria-de-peru.

Usinas Siderúrgicas de Minas Gerais S.A., 2009, Relatorio anual 2008 [Annual report 2008], Usinas Siderúrgicas de Minas Gerais S.A. 83 p., accessed June 2016 at http://ri.usiminas.com/enu/arquivos/relatorios/relatorio_anual_2008.pdf.

Usinas Siderúrgicas de Minas Gerais S.A., 2011, Relatorio anual 2010 [Annual report 2010], Usinas Siderúrgicas de Minas Gerais S.A. 167 p., accessed June 2016 at http://ri.usiminas.com/enu/arquivos/relatorios/AnnualReport2010.pdf.

*U.S. Department of Energy, National Renewable Energy Laboratory, 2015, Energy Transition Initiative—Islands—Belize: U.S. Department of Energy, National Renewable Energy Laboratory Fact Sheet DOE/GO–102015–4582, 4 p., accessed February 6, 2017, at http://www.nrel.gov/docs/fy15osti/62707.pdf.

*U.S. Department of State, 2017, Africa and Americas—Simplified Large Scale International Boundaries (LSIB) Polygons: U.S. Department of State Humanitarian Information Unit, U.S. Department of State web page, accessed April 24, 2017, at https://data.humdata.org/dataset/africaamericas-lsib-polygons-simplified-2017mar30.

U.S. Geological Survey, 2016, Mineral commodity summaries 2016: U.S. Geological Survey, 202 p., accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/mcs/2016/mcs2016.pdf.

U.S. Geological Survey and Corporación Venezolana de Guayana, Técnica Minera C.A., 1993, Geology and mineral resource assessment of the Venezuelan Guayana Shield: U.S. Geological Survey Bulletin 2062, 121 p., 8 pls., accessed April 24, 2017, at https://pubs.er.usgs.gov/publication/b2062.

U.S. Geological Survey and Geological Survey of Guyana, 1976, Merumite—A complex assemblage of chromium minerals from Guyana: U.S. Geological Survey Professional Paper 887, 49 p., accessed April 25, 2017, at https://pubs.usgs.gov/pp/0887/report.pdf.

U.S. Geological Survey and Servicio Geológico de Bolivia, 1992, Geology and mineral resources of the Altiplano and Cordillera Occidental, Bolivia, *with a section on* Application of economic evaluations to deposit models, by D.I. Bleiwas and R.G. Christiansen: U.S. Geological Survey Bulletin 1975, 365 p., 8 pls. in pocket, accessed April 24, 2017, at https://pubs.er.usgs.gov/publication/b1975.

U.S. Geological Survey and Servicio Geologico Nacional de Colombia, 1969, Phosphate rock in Colombia—A preliminary report: U.S. Geological Survey Bulletin 1272–A, 86 p., 3 pls. in pocket, accessed April 25, 2017, at https://pubs.usgs.gov/bul/1272a/report.pdf.

U.S. Geological Survey, Dirección General de Geología, Minas y Hidrocarburos, and Universidad de Costa Rica, 1987, Mineral Resource Assessment of the Republic of Costa Rica [Evaluación de los Recursos Minerales de la República de Costa Rica]: U.S. Geological Survey Miscellaneous Investigations Series Map I–1865, 78 p., 10 pls., accessed April 25, 2017, at https://pubs.usgs.gov/imap/1865/report.pdf.

*U.S. Geological Survey World Conventional Resources Assessment Team, 2013, Supporting data for the U.S. Geological Survey 2012 world assessment of undiscovered oil and gas resources: U.S. Geological Survey Digital Data Series DDS–69–FF, various pages, accessed May 2016 at https://pubs.usgs.gov/dds/dds-069/dds-069-ff/.

*U.S. Geological Survey World Energy Assessment Team, 2000, U.S. Geological Survey world petroleum assessment 2000—Description and results: U.S. Geological Survey Digital Data Series DDS−60, 4 CD-ROMs, accessed May 2016 at https://pubs.usgs.gov/dds/dds-060/.

Vale Overseas Ltd., 2002, Annual report 2001: Rio de Janeiro, Brazil, Vale S.A., 250 p., accessed June 6, 2016, at http://www.vale.com/EN/investors/information-market/annual-reports/20f/20FDocs/F2001i.pdf.

Vale S.A., 2012a, Vale: constructing a brand, chap. 10, Vale our history: Rio de Janeiro, Brazil, Vale S.A., p. 335–417, accessed April 9, 2017, at http://www.vale.com/EN/aboutvale/book-our-history/Documents/livro/valehistorybook10.pdf.

Vale S.A., 2012b, Vale: the creation of Companhia Vale do Rio Doce, chap. 2, Vale our history: Rio de Janeiro, Brazil, Vale S.A., p. 41–73, accessed April 9, 2017, at http://www.vale.com/EN/aboutvale/book-our-history/Documents/livro/valehistorybook2.pdf.

Vale S.A., 2012c, Vale: mining in the First Republic, chap. 1, Vale our history: Rio de Janeiro, Brazil, Vale S.A., p. 17–40, accessed April 9, 2017, at http://www.vale.com/EN/aboutvale/book-our-history/Documents/livro/valehistorybook.pdf.

Vale S.A., 2016a, Form 20–F for the fiscal year ended December 31, 2015: U.S. Securities and Exchange Commission, accessed April 9, 2017, at http://www.vale.com/EN/investors/information-market/annual-reports/20f/20FDocs/Vale%2020-F%202015_i.PDF.

Vale S.A., 2016b, Vale across the world: Vale S.A., accessed April 9, 2017, at http://www.vale.com/en/aboutvale/across-world/pages/default.aspx.

Viscidi, Lisa, Sucre, Carlos, and Karst, Sean, 2015, Natural gas market outlook—How Latin America and the Caribbean can benefit from the U.S. shale boom: The Inter-American Dialogue and the Inter-American Development Bank, 15 p., September 2015, accessed September 2016 at http://www.thedialogue.org/wp-content/uploads/2015/09/Natural-Gas-Market-Outlook.pdf.

*Wacaster, Susan, 2015a, The mineral industry of Argentina [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbook 2013, v. III, p. 2.1–2.11, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-ar.pdf.

*Wacaster, Susan, 2015b, The mineral industry of Chile [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 7.1–7.19, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-ci.pdf.

*Wacaster, Susan, 2015c, The mineral industry of Colombia [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 8.1–8.8, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-co.pdf.

*Wacaster, Susan, 2016a, The mineral industry of Bolivia [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2013, v. III, p. 3.1–3.12, accessed April 2016 at https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-bl.pdf.

*Wacaster, Susan, 2016b, The mineral industry of Central America—Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2014, v. III, p. 7.1–7.8, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2014/myb3-2014-bh-cs-es-gt-ho-nu-pm.pdf.

*Wacaster, Susan, 2016c, The mineral industry of Ecuador [advance release], *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbok 2014, v. III, p. 12.1–12.5, accessed March 7, 2016, at https://minerals.usgs.gov/minerals/pubs/country/2014/myb3-2014-ec.pdf.

Wacaster, Susan, Baker, M.S., Soto-Viruet, Yadira, and Textoris, Steven, 2015, Recent trends in Cuba's mining and petroleum industries (ver. 1.1, April 9, 2015): U.S. Geological Survey Fact Sheet 2015–3032, 6 p., accessed March 2016 at https://doi.org/10.3133/fs20153032.

Wacaster, Susan, Soto-Viruet, Yadira, Perez, A.A., Anderson, S.T., Gurmendi, A.C., Mobbs, P.M., Wallace, G.J., and Wilburn, D.R., 2014, The mineral industries of Latin America and Canada, *in* Area reports—International—Latin America and Canada: U.S. Geological Survey Minerals Yearbook 2012, v. III, p. 1.1–1.26, accessed June 2016 at http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-sum-2012-latin-canada.pdf.

Wallace, R.M., 1976, Geological reconnaissance of some Uruguayan iron and manganese deposits in 1962: U.S. Geological Survey Open-File Report 76-466, 32 p., 1 pl., accessed April 25, 2017, at https://pubs.usgs.gov/of/1976/0466/report.pdf.

*Weaver, J.N., and Wood, G.H., Jr., 1994, Coal map of South America: U.S. Geological Survey Coal Investigations Map C–145, accessed March 15, 2017, at https://pubs.er.usgs.gov/publication/coal145.

Wheeler, Brian, 2012, Hydro powers Latin America: Renewable Energy World, June 21, 2012, accessed Auguust 2016 at http://www.renewableenergyworld.com/articles/2012/06/hydro-powers-latin-america.html.

Wilburn, D.R., Bleiwas, D.I., and Karl, N.A., 2016, Global stocks of selected mineral-based commodities: U.S. Geological Survey Scientific Investigations Report 2016–5152, 13 p., accessed March 24, 2016, at https://doi.org/10.3133/sir20165152.

Wilburn, D.R., and Karl, N.A., 2016, Exploration review, *in* Annual review 2015: Mining Engineering, v. 68, no. 5, p. 30–51, accessed March 24, 2016, at https://minerals.usgs.gov/minerals/mflow/exploration-2015.pdf.

*Wilburn, D.R., Rapstine, T.D., and Lee, E.C., 2012, Exploration review, *in* Annual review 2011: Mining Engineering, v. 64, no. 5, p. 28–48, accessed March 24, 2016, at https://minerals.usgs.gov/minerals/mflow/exploration-2011.pdf.

*Wilburn, D.R., and Stanley, K.A., 2013, Exploration review, *in* Annual review 2012: Mining Engineering, v. 65, no. 5, p. 22–42, accessed March 24, 2016, at https://minerals.usgs.gov/minerals/mflow/exploration-2012.pdf.

*Wilburn, D.R., and Stanley, K.A., 2014, Exploration review, *in* Annual review 2013: Mining Engineering, v. 66, no. 5, p. 18–39, accessed March 24, 2016, at https://minerals.usgs.gov/minerals/mflow/exploration-2013.pdf.

*Wilburn, D.R., Stanley, K.A., and Karl, N.A., 2015, Exploration review, *in* Annual review 2014: Mining Engineering, v. 67, no. 5, p. 16–38, accessed March 24, 2016, at https://minerals.usgs.gov/minerals/mflow/exploration-2014.pdf.

Wilmot, R.C., Sullivan, A.C., and Trought, M.E., 1959, Bauxite, *in* Metals and minerals: Bureau of Mines Minerals Yearbook 1958, v. I, p. 209–227, accessed June 6, 2016, at http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=turn&entity=EcoNatRes.MinYB1958v1.p0218&id=EcoNatRes.MinYB1958v1&isize=M.

Yepez-García, R.A., Johnson, T.M., and Andrés, L.A., 2010, Meeting the electricity supply/demand balance in Latin America and the Caribbean: The World Bank, September 2010, 144 p., accessed April 24, 2017, at https://www.esmap.org/sites/esmap.org/files/REPORT%20LAC%20Electricity%20Challenge%20octubre%202010%20LESMAP%20FINAL.pdf.

Appendixes

Appendix 1— Data tables 1–1 through 1–7

Table 1–1. Global reserve estimates (2015) and mine production (2014–15) of nonfuel mineral commodities for countries of Latin America and the Caribbean, by commodity and country.

[From the USGS Mineral Commodity Summaries, 2016. CPPGP, country production as percent of global production; %, percent; kg, kilogram; mt, metric ton; NA, not available. Data are rounded to no more than three significant digits. Units are thousand metric tons (tmt) of metal content or of the industrial mineral, unless otherwise specified]

Country	Mineral commodity	2015 reserve estimates				Production data						Unit	Comments
						2014			2015 (preliminary estimates)				
		Reserve estimate	Global rank	Global reserve estimate	Percent of global reserve estimate	Country production	Global production	CPPGP	Country production	Global production	CPPGP		
Bolivia	Antimony	310	3	2,000	16.0	5.5	158	3.5	5	150	3.3		2014 production estimated.
Mexico	Barite	7,000	8	380,000	2.0	420	8,250	5.1	220	7,460	2.9		
Peru	Barite	NA	NA	380,000	NA	106	8,250	1.3	100	7,460	1.0		
Brazil	Bauxite	2,600,000	3	28,000,000	9.3	34,800	245,000	14.2	35,000	274,000	13.0		
Guyana	Bauxite	850,000	7	28,000,000	3.0	1,600	245,000	0.7	1,700	274,000	0.6	thousand metric tons dry	
Jamaica	Bauxite	2,000,000	5	28,000,000	7.1	9,680	245,000	4.0	10,700	274,000	3.9	thousand metric tons dry	
Suriname	Bauxite	580,000	10	28,000,000	2.1	3,000	245,000	1.2	2,200	274,000	0.8	thousand metric tons dry	
Venezuela	Bauxite	320,000	11	28,000,000	1.1	1,500	245,000	0.6	1,500	274,000	0.5	thousand metric tons dry	
Bolivia	Bismuth	10	4	370	3.0	0.01	13.6	0.1	0.010	13.6	0.1		
Mexico	Bismuth	10	5	370	3.0	0.948	13.6	7.0	0.7	13.6	5.1		
Argentina	Boron	NA	NA	380,000	NA	500	5,860	9.0	500	5,960	8.4	thousand metric tons gross weight	Global production totals exclude U.S. production.
Bolivia	Boron	NA	NA	380,000	NA	15	5,860	0.3	15	5,960	0.3	thousand metric tons gross weight	Global production totals exclude U.S. production.
Chile	Boron	35,000	4	380,000	9.0	580	5,860	10.0	580	5,960	9.7	thousand metric tons gross weight	Global production totals exclude U.S. production.

Table 1–1. Global reserve estimates (2015) and mine production (2014–15) of nonfuel mineral commodities for countries of Latin America and the Caribbean, by commodity and country.—Continued

[From the USGS Mineral Commodity Summaries, 2016. CPPGP, country production as percent of global production; %, percent; kg, kilogram; mt, metric ton; NA, not available. Data are rounded to no more than three significant digits. Units are thousand metric tons (tmt) of metal content or of the industrial mineral, unless otherwise specified]

Country	Mineral commodity	2015 reserve estimates				Production data						Unit	Comments
						2014			2015 (preliminary estimates)				
		Reserve estimate	Global rank	Global reserve estimate	Percent of global reserve estimate	Country production	Global production	CPPGP	Country production	Global production	CPPGP		
Peru	Boron	4,000	6	380,000	1.0	225	5,860	3.8	225	5,960	3.8	thousand metric tons gross weight	Global production totals exclude U.S. production.
Mexico	Cadmium	NA	NA	NA	NA	1.41	24.2	5.8	1.46	24.2	6.0		
Peru	Cadmium	NA	NA	NA	NA	0.769	24.2	3.2	0.75	24.2	3.1		
Brazil	Cobalt	78	11	7,100	1.0	2.6	123	2.1	2.6	124	2.1		
Cuba	Cobalt	500	3	7,100	7.0	3.7	123	3.0	4.2	124	3.4		
Chile	Copper	210,000	1	720,000	29.0	5,750	18,500	31.0	5,700	18,700	31.0		
Mexico	Copper	46,000	4	720,000	6.4	515	18,500	2.8	550	18,700	3.0		
Peru	Copper	82,000	3	720,000	11.0	1,380	18,500	7.5	1,600	18,700	8.6		
Mexico	Fluorspar	32,000	2	250,000	13.0	1,110	6,390	17.4	1,110	6,250	17.8		Reserves measured as 100% calcium fluoride.
Brazil	Gold	2,400	7	56,000	4.3	80	2,990	2.7	80	3,000	3.0	metric tons of gold content	
Mexico	Gold	1,400	11	56,000	2.5	118	2,990	3.9	120	3,000	4.0	metric tons of gold content	
Peru	Gold	2,800	6	56,000	5.0	140	2,990	4.7	150	3,000	5.0	metric tons of gold content	
Brazil	Graphite	72,000	2	230,000	31.0	80	1,190	7.0	80	1,190	7.0		
Mexico	Graphite	3,100	5	230,000	1.0	22	1,190	2.0	22	1,190	2.0		
Chile	Iodine	1,800	2	75,000	2.4	20	30.3	66.0	20	30.3	66.0		Measured in elemental iodine.
Brazil	Iron ore	23,000	3	190,000	12.0	411	3,420	12.0	428	3,320	13.0	million metric tons gross weight of crude ore	Reserves are of crude ore. Iron content of reserves for Brazil is 12 billion metric tons.

Table 1–1. Global reserve estimates (2015) and mine production (2014–15) of nonfuel mineral commodities for countries of Latin America and the Caribbean, by commodity and country.—Continued

[From the USGS Mineral Commodity Summaries, 2016. CPPGP, country production as percent of global production; %, percent; kg, kilogram; mt, metric ton; NA, not available. Data are rounded to no more than three significant digits. Units are thousand metric tons (tmt) of metal content or of the industrial mineral, unless otherwise specified]

Country	Mineral commodity	2015 reserve estimates				Production data						Unit	Comments
						2014			2015 (preliminary estimates)				
		Reserve estimate	Global rank	Global reserve estimate	Percent of global reserve estimate	Country production	Global production	CPPGP	Country production	Global production	CPPGP		
Bolivia	Lead	1,600	9	89,000	1.8	94	4,870	1.9	82	4,710	1.7		
Mexico	Lead	5,600	5	89,000	6.3	250	4,870	5.0	240	4,710	5.0		
Peru	Lead	6,700	4	89,000	7.5	278	4,870	5.7	300	4,710	6.0		
Argentina	Lithium	2	3	14	14.0	3.2	31.7	10.0	3.8	32.5	12.0		
Brazil	Lithium	0.048	6	14	0.3	0.16	31.7	0.5	0.16	32.5	0.5		
Chile	Lithium	7.5	1	14	54.0	11.5	31.7	36.0	11.7	32.5	36.0		
Brazil	Magnesium compounds	86,000	7	2,400,000	3.6	175	8,420	2.0	175	8,300	2.0		
Brazil	Manganese	50,000	5	620,000	8.1	1,040	17,800	6.0	1,000	18,000	6.0	thousand metric tons gross weight	
Mexico	Manganese	5,000	9	620,000	0.8	236	17,800	1.0	240	18,000	1.3	thousand metric tons gross weight	
Chile	Molybdenum	1,800	3	11,000	16.0	48.8	281	17.0	49	267	18.0		
Mexico	Molybdenum	130	11	11,000	1.0	14.4	281	5.0	13	267	4.9		
Peru	Molybdenum	450	4	11,000	4.0	17	281	6.0	18.1	267	6.8		
Brazil	Nickel	10,000	2	79,000	13.0	102	2,450	4.2	110	2,530	4.0		
Colombia	Nickel	1,100	13	79,000	1.4	81	2,450.0	3.3	73	2,530	3.0		
Cuba	Nickel	5,500	5	79,000	7.0	50.4	2,450.0	2.0	57	2,530	2.0		
Guatemala	Nickel	1,800	11	79,000	2.3	38.4	2,450.0	1.6	50	2,530	2.0		
Brazil	Niobium (columbium)	4,100	1	4,300	95.0	50	55.9	89.0	50	56	89.0		Global reserves greater than 4,300,000 metric tons of niobium content.
Brazil	Phosphate rock	320,000	14	69,000,000	0.5	6,040	218,000	3.0	6,700	223,000	3.0		

Table 1–1. Global reserve estimates (2015) and mine production (2014–15) of nonfuel mineral commodities for countries of Latin America and the Caribbean, by commodity and country.—Continued

[From the USGS Mineral Commodity Summaries, 2016. CPPGP, country production as percent of global production; %, percent; kg, kilogram; mt, metric ton; NA, not available. Data are rounded to no more than three significant digits. Units are thousand metric tons (tmt) of metal content or of the industrial mineral, unless otherwise specified]

Country	Mineral commodity	2015 reserve estimates				Production data						Unit	Comments
						2014			2015 (preliminary estimates)				
		Reserve estimate	Global rank	Global reserve estimate	Percent of global reserve estimate	Country production	Global production	CPPGP	Country production	Global production	CPPGP		
Mexico	Phosphate rock	30,000	20	69,000,000	0.0	1,700	218,000	0.8	1,700	223,000	0.8		
Peru	Phosphate rock	820,000	12	69,000,000	1.2	3,800	218,000	1.7	4,000	223,000	2.0		
Brazil	Potash	13,000	13	3,700,000	0.4	311	38,800	0.8	311	38,800	0.8	tmt of K_2O equivalent	Reserves of recoverable ore equal 300 million metric tons.
Chile	Potash	150,000	8	3,700,000	4.0	1,200	38,800	3.0	1,200	38,800	3.0	tmt of K_2O equivalent	Reserves of recoverable ore not available for Chile.
Brazil	Rare earths	22,000	2	130,000	17.0	NA	123	NA	NA	124	NA	tmt of rare-earth oxide (REO) equivalent	
Chile	Rhenium	1,300,000	1	2,500,000	52.0	25,000	44,700	56.0	26,000	46,000	57.0	kg of rhenium content	Estimated amount recovered with copper and molybdenum production; excludes secondary rhenium.
Peru	Rhenium	45,000	5	2,500,000	2.0	NA	44,700	NA	NA	46,000	NA	kg of rhenium content	Estimated amount recovered with copper and molybdenum production; excludes secondary rhenium.

Table 1–1. Global reserve estimates (2015) and mine production (2014–15) of nonfuel mineral commodities for countries of Latin America and the Caribbean, by commodity and country.—Continued

[From the USGS Mineral Commodity Summaries, 2016. CPPGP, country production as percent of global production; %, percent; kg, kilogram; mt, metric ton; NA, not available. Data are rounded to no more than three significant digits. Units are thousand metric tons (tmt) of metal content or of the industrial mineral, unless otherwise specified]

Country	Mineral commodity	2015 reserve estimates				Production data						Unit	Comments
						2014			2015 (preliminary estimates)				
		Reserve estimate	Global rank	Global reserve estimate	Percent of global reserve estimate	Country produc-tion	Global produc-tion	CPPGP	Country produc-tion	Global produc-tion	CPPGP		
Chile	Selenium	25,000	2	120,000	21.0	41	NA	NA	50	NA	NA	mt of selenium content	Selenium content of refineray production.
Peru	Selenium	13,000	4	120,000	11.0	49	NA	NA	50	NA	NA	mt of selenium content	Selenium content of refineray production.
Bolivia	Silver	22	8	570	4.0	1.34	26.8	5.0	1.3	27.3	5.0		
Chile	Silver	77	4	570	14.0	1.57	26.8	6.0	1.6	27.3	6.0		
Mexico	Silver	37	6	570	6.5	5	26.8	19.0	5.4	27.3	20.0		
Peru	Silver	120	1	570	21.0	3.78	26.8	14.0	3.8	27.3	14.0		
Brazil	Tantalum	36,000	2	100,000	36.0	150	1,200	13.0	150	1,200	13.0	mt of tantalum content	Global reserves greater than 100,000 mt of tantalum content.
Peru	Tellurium	3,600	1	25,000	14.0	NA	NA	NA	NA	NA	NA	mt of tellurium content	Tellurium content of refinery production.
Bolivia	Tin	400	4	4,800	8.0	19.9	286	7.0	20	294	7.0		
Brazil	Tin	700	3	4,800	15.0	14.7	286	5.0	17	294	6.0		
Peru	Tin	130	9	4,800	3.0	23.1	286	8.0	22.5	294	8.0		
Brazil	Titanium mineral concentrates (Ilmenite)	43,000	6	740,000	6.0	100	5,570	2.0	100	5,610	2.0	tmt of contained TiO_2	
Bolivia	Zinc	4,600	8	200,000	2.0	449	13,300	3.0	430	13,400	3.0		
Mexico	Zinc	15,000	4	200,000	8.0	660	13,300	5.0	660	13,400	5.0		
Peru	Zinc	25,000	3	200,000	13.0	1,320	13,300	10.0	1,370	13,400	10.0		

Table 1–2. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from gas-only fields, by country within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

Country	Total number of gas-only fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
Argentina	322	NA	NA	547	915	57	74
Barbados	12	NA	NA	LT1	LT1	LT1	LT1
Belize	NA	NA	NA	NA	NA	NA	NA
Bolivia	68	NA	NA	338	1,480	52	159
Brazil	270	NA	NA	71	888	7	138
Chile	107	NA	NA	184	264	8	13
Colombia	72	NA	NA	212	488	86	126
Costa Rica	NA	NA	NA	NA	NA	NA	NA
Cuba	NA	NA	NA	NA	NA	NA	NA
Dominican Republic	1	NA	NA	W	W	W	W
Ecuador	4	NA	NA	NA	222	NA	67
Falkland Islands (United Kingdom)	NA	NA	NA	NA	NA	NA	NA
French Guiana	NA	NA	NA	NA	NA	NA	NA
Guatemala	2	NA	NA	NA	LT1	NA	LT1
Guyana	NA	NA	NA	NA	NA	NA	NA
Mexico	557	NA	NA	700	1,040	22	84
Nicaragua	NA	NA	NA	NA	NA	NA	NA
Paraguay	4	NA	NA	NA	6	NA	1
Peru	28	NA	NA	73	754	39	206
Suriname	NA	NA	NA	NA	NA	NA	NA
Trinidad and Tobago	59	NA	NA	567	1,290	12	95
Venezuela	81	NA	NA	245	1,740	18	197
Total	**1,587**	**NA**	**NA**	**2,940**	**9,080**	**302**	**1,160**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Table 1–3. Cumulative production and recoverable proven plus probable resources of extra-heavy crude resources from oil fields, by country within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes conventional and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

Country	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
Brazil	1	NA	W	NA	W	NA	NA
Colombia	6	2	65	LT1	LT1	NA	NA
Ecuador	1	NA	W	NA	W	NA	NA
Mexico	18	LT1	228	LT1	5	NA	NA
Trinidad and Tobago	1	NA	W	NA	W	NA	NA
Venezuela	33	566	43,000	17	627	NA	NA
Total	**60**	**568**	**43,200**	**17**	**634**	**NA**	**NA**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Table 1–4. Cumulative production and recoverable proven plus probable resources of unconventional hydrocarbon resources from oil fields, by country within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes conventional and extra-heavy crude resources. Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

Country	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
Argentina	77	162	485	443	716	36	58
Brazil	5	NA	1	NA	5	NA	LT1
Chile	10	LT1	1	1	9	LT1	2
Colombia	6	NA	NA	LT1	4	NA	NA
Falkland Islands (United Kingdom)	1	NA	NA	NA	W	NA	W
Mexico	16	LT1	LT1	1	23	NA	LT1
Total	**115**	**162**	**486**	**446**	**W**	**36**	**W**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Table 1–5. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from gas-only fields, by petroleum province within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of gas-only fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
5300	Burgos Basin	357	NA	NA	365	476	4	43
5301	Tampico-Misantla Basin	21	NA	NA	4	12	NA	LT1
5302	Veracruz Basin	63	NA	NA	101	225	LT1	4
5304	Saline-Comalcalco Basin	9	NA	NA	LT1	6	NA	LT1
5305	Villahermosa Uplift	20	NA	NA	41	58	17	19
5306	Macuspana Basin	36	NA	NA	170	184	LT1	17
5307	Campeche-Sigsbee Salt Basin	2	NA	NA	NA	9	NA	LT1
5308	Yucatán Platform	NA	NA	NA	NA	NA	NA	NA
5310	Sierra Madre de Chiapas-Peten Foldbelt	4	NA	NA	NA	4	NA	3
5313	Sierra Madre Oriental Foldbelt	NA	NA	NA	NA	NA	NA	NA
5314	Jalisco-Oaxaca Platform	1	NA	NA	NA	W	NA	W
5321	Coahuila Platform	6	NA	NA	NA	LT1	NA	LT1
5323	Sabinas Basin	33	NA	NA	19	21	NA	LT1
5332	Salton Trough	2	NA	NA	NA	LT1	NA	LT1
5334	Vizcaíno Basin	2	NA	NA	NA	LT1	NA	LT1
6010	Takutu Basin	NA	NA	NA	NA	NA	NA	NA
6011	Solimões Basin	37	NA	NA	LT1	66	LT1	3
6012	Amazonas Basin	10	NA	NA	NA	23	NA	1
6016	Parnaíba Basin	19	NA	NA	3	57	LT1	LT1
6020	Paraná Basin	11	NA	NA	NA	1	NA	LT1
6021	Guyana-Suriname Basin	NA	NA	NA	NA	NA	NA	NA
6022	Foz do Amazonas Basin	6	NA	NA	NA	31	NA	LT1
6023	Santana Platform	1	NA	NA	NA	W	NA	NA
6025	Barreirinhas Basin	4	NA	NA	NA	3	NA	LT1
6026	Ceará Basin	8	NA	NA	NA	3	NA	LT1
6027	Potiguar Basin	27	NA	NA	2	27	LT1	3
6029	Sergipe-Alagoas Basin	39	NA	NA	7	26	LT1	2
6031	Tucano Basin	4	NA	NA	LT1	LT1	LT1	LT1
6032	Recôncavo Basin	41	NA	NA	24	49	LT1	1
6033	Bahia Sul Basin	7	NA	NA	NA	23	NA	2
6034	Espírito Santo Basin	24	NA	NA	16	84	2	10
6035	Campos Basin	16	NA	NA	LT1	69	NA	64
6036	Santos Basin	16	NA	NA	16	426	4	51
6038	Santiago Basin	1	NA	NA	NA	W	NA	W

Table 1–5. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from gas-only fields, by petroleum province within Latin America and the Caribbean.—Continued

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of gas-only fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
6039	Huallaga Basin	1	NA	NA	NA	W	NA	NA
6040	Ucayali Basin	8	NA	NA	33	261	13	83
6041	Putumayo-Oriente-Maranon Basin	NA	NA	NA	NA	NA	NA	NA
6043	Madre de Dios Basin	4	NA	NA	40	442	25	123
6044	Beni Basin	NA	NA	NA	NA	NA	NA	NA
6045	Santa Cruz-Tarija Basin	89	NA	NA	521	1,720	82	193
6046	Oran-Olmedo Basin	4	NA	NA	LT1	6	LT1	LT1
6051	Cuyo Basin	1	NA	NA	W	W	NA	NA
6055	Neuquén Basin	176	NA	NA	101	200	9	13
6058	San Jorge Basin	29	NA	NA	3	9	LT1	LT1
6059	Magallanes Basin	197	NA	NA	444	733	26	39
6060	Falklands Plateau	4	NA	NA	NA	222	NA	67
6063	Malvinas Basin	1	NA	NA	NA	W	NA	W
6065	Altiplano Basin	NA	NA	NA	NA	NA	NA	NA
6069	Temuco Basin	1	NA	NA	NA	W	NA	NA
6074	Central Chile Forearc Basin	3	NA	NA	NA	1	NA	LT1
6080	Sechura Basin	2	NA	NA	NA	9	NA	LT1
6081	Talara Basin	9	NA	NA	LT1	40	NA	LT1
6083	Progreso Basin	4	NA	NA	5	12	LT1	LT1
6087	Choco Pacific Basin	NA	NA	NA	NA	NA	NA	NA
6089	Upper Magdalena Valley Basin	4	NA	NA	LT1	LT1	NA	LT1
6090	Middle Magdalena Valley Basin	9	NA	NA	1	6	LT1	LT1
6091	Lower Magdalena Valley Basin	36	NA	NA	26	75	LT1	1
6093	Perijá-Venezuela-Coastal Ranges	1	NA	NA	NA	5	NA	LT1
6094	Cesar Basin	2	NA	NA	NA	LT1	NA	LT1
6095	Guarija Basin	8	NA	NA	147	479	LT1	34
6096	Llanos Basin	9	NA	NA	39	197	86	124
6097	Barinas-Apure Basin	3	NA	NA	1	17	LT1	1
6098	East Venezuela Basin	107	NA	NA	751	2,380	29	247
6099	Maracaibo Basin	13	NA	NA	6	22	1	2
6100	Falcon Basin	4	NA	NA	NA	8	NA	LT1

Table 1–5. Cumulative production and recoverable proven plus probable resources of conventional hydrocarbon resources from gas-only fields, by petroleum province within Latin America and the Caribbean.—Continued

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes extra-heavy crude and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of gas-only fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
6102	Cariaco Basin	3	NA	NA	NA	6	NA	LT1
6103	Tobago Trough	12	NA	NA	52	299	LT1	9
6104	South Caribbean Deformed Belt	1	NA	NA	NA	W	NA	W
6106	West-Central Cordillera	NA	NA	NA	NA	NA	NA	NA
6107	Lesser Antilles Deformed Belt	12	NA	NA	LT1	LT1	LT1	LT1
6114	North Nicaraguan Rise	NA	NA	NA	NA	NA	NA	NA
6117	Greater Antilles Deformed Belt	NA	NA	NA	NA	NA	NA	NA
Total		**1,580**	**NA**	**NA**	**2,941**	**9,050**	**302**	**1,150**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Table 1–6. Cumulative production and recoverable proven plus probable resources of extra-heavy crude from oil fields, by petroleum province within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes conventional and unconventional resources (coalbed methane, shale gas, tight gas, shale oil, and tight oil). Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
5304	Saline-Comalcalco Basin	3	NA	3	NA	LT1	NA	NA
5305	Villahermosa Uplift	10	LT1	168	LT1	3	NA	NA
5307	Campeche-Sigsbee Salt Basin	5	NA	57	NA	2	NA	NA
6036	Santos Basin	1	NA	W	NA	W	NA	NA
6041	Putumayo-Oriente-Maranon Basin	3	LT1	100	NA	1	NA	NA
6096	Llanos Basin	4	1	47	LT1	LT1	NA	NA
6098	East Venezuela Basin	34	566	42,800	17	627	NA	NA
Total		**60**	**568**	**W**	**17**	**W**	**NA**	**NA**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Table 1–7. Cumulative production and recoverable proven plus probable resources of unconventional hydrocarbon resources from oil fields, by petroleum province within Latin America and the Caribbean.

[Data derived from IHS International Exploration and Production Database; used with permission from IHS Global, Inc.[1] (IHS Global Inc., 2016). Excludes conventional and extra-heavy crude resources. Data for oil and condensate in million cubic meters (MCM); data for gas in billion cubic meters (BCM). LT1, less than one unit; NA, not available; RPP, recoverable proven plus probable resources; W, data withheld to conceal proprietary data. Data are rounded to no more than three significant digits; may not add to totals shown. Data are unrounded for grand total of number of fields]

USGS petroleum province code	USGS petroleum province name	Total number of oil fields	Cumulative oil production (MCM)	Oil RPP (MCM)	Cumulative gas production (BCM)	Gas RPP (BCM)	Cumulative condensate production (MCM)	Condensate RPP (MCM)
5300	Burgos Basin	14	LT1	LT1	LT1	16	NA	LT1
5323	Sabinas Basin	2	NA	NA	1	7	NA	LT1
6017	São Francisco Basin	1	NA	NA	NA	W	NA	W
6032	Recôncavo Basin	4	NA	1	NA	LT1	NA	LT1
6055	Neuquén Basin	70	79	368	420	681	36	57
6058	San Jorge Basin	7	83	117	23	35	NA	1
6059	Magallanes Basin	10	LT1	1	1	9	LT1	2
6060	Falklands Plateau	1	NA	NA	NA	W	NA	W
6093	Perijá-Venezuela-Coastal Ranges	2	NA	NA	LT1	LT1	NA	NA
6094	Cesar Basin	4	NA	NA	LT1	3	NA	NA
Total		**115**	**162**	**486**	**446**	**785**	**36**	**61**

[1]In July 2016, the parent company of IHS Global, IHS Inc., merged with Markit Ltd. to become IHS Markit. These data were accessed and acquired in early 2016, prior to the finalization of this merger.

Appendix 2—Case study 1: Iron ore mining and transportation infrastructure in Brazil's Iron Quadrangle

Geologic overview

The Iron Quadrangle is a mountainous mining region located in the south-central part of the State of Minas Gerais, Brazil. The Iron Quadrangle is rich in iron ore, along with deposits of gold and manganese. Iron ore deposits in this area occur as a metamorphosed Precambrian banded iron formation, known as itabirite. Itabirite contains bands of hematite that range from millimeters to centimeters in thickness over long distances. Iron ore is extracted by open pit mining and the majority of the ore is concentrated locally. Further processing or pelletizing occurs locally at a few facilities, though a majority of material is processed near coastal ports (Dorr and Barbosa, 1963; Vale S.A., 2012a, p. 397).

Country background

In 2015, Brazil had a population of more than 200 million people and a land area of about 8.4 million km^2. For the same year, Brazil was estimated to be the world's third largest producer of iron ore behind China and Australia, contributing about 13 percent of the world's total production. Iron ore accounted for over 87 percent of the country's mineral exports by value. Of the approximately 411 Mt of iron ore produced in Brazil in 2014, nearly 72 percent of it was exported. The country's main export partners for iron ore were China, which accounted for 55 percent of Brazil's total iron ore exports, followed by Japan, South Korea, and the Netherlands, each accounting for less than 10 percent of Brazil's total iron exports (Tuck, 2016; Departamento Nacional de Produção Mineral, 2016, p. 9, 67).

Historical perspective, pre-1950

Interest in mining in the area of the Iron Quadrangle began with the discovery of gold in the region in the 1720s. It was not until the early 20th century that specific interest in the rich iron ore deposits of the region began to grow. In 1910, at the 11th International Geological Congress, the Geological and Mineralogical Service of Brazil presented a report identifying the locations of iron ore deposits in Minas Gerais and outlining their economic potential. For the first time, these deposits became internationally known, with the report garnering the attention of American and European mining companies (Dorr and Barbosa, 1963, p. C4; Vale S.A., 2012c, p. 27).

The first company to demonstrate interest in the iron ore deposits was the United Kingdom-based Brazilian Hematite Syndicate (BHS), which acquired 42,000 shares in the Estrada de Ferro Vitória a Minas (EFVM) railroad company in 1910. The BHS made a request to the Brazilian Government to change the route of the original railroad to include Itabira, the city closest to the deposits. After the request was granted, the BHS acquired nearly 77 km^2 of land near Itabira which contained the major iron ore deposits known at the time, consisting of more than 1 Gt of ore. The syndicate incorporated as the London-based Itabira Iron Ore Co., which in 1911 received authorization from the Brazilian Government to operate within the country.

Development, however, did not begin owing to the start of World War I, which cut the project off from potential funding from European sources. Following the war, the Itabira Iron Ore Co. signed a contract with the Brazilian Government granting the company the right to construct and operate mines in the Itabira region; however, ratification of the contract was delayed owing to internal nationalist opposition to the company. The global economic depression of the 1930s further restricted funding for the project, and in 1939 the government voided the contract with the company through Decree Law No. 1,507 (Vale S.A., 2012c, p. 29; 2012b).

In 1942, with fears that a German invasion of Spain and North Africa would cut off the United Kingdom's more proximal sources of iron ore, the United States, the United Kingdom, and Brazil signed the Washington Agreements. As part of these agreements, the British Government purchased Itabira Iron Ore Co. and EFVM and transferred the ownership to the Brazilian Government, which went on to form Companhia Vale do Rio Doce (CVRD), the precursor to Vale S.A. The role of CVRD was to manage EFVM and the mines originally owned by Itabira Iron Ore Co. The new company was divided into 85 percent public offering through shares and 15 percent private capital. Within nine years, CVRD became the leading exporter of iron ore in Brazil, increasing from 11 percent of total iron ore shipped in 1942 to over 81 percent in 1950. Total iron ore exports also greatly expanded for the country, from about 316,000 t exported in 1942 to 890,000 t exported in 1950 (Dorr and Barbosa, 1963, p. C5.; Vale S.A., 2012b). For comparison, approximately 296 Mt of iron ore was exported from Brazil in 2014 (Departamento Nacional de Produção Mineral, 2016, p. 9, 67).

Mineral production facilities, post-1950

Mines

In 2014, nine companies were operating over 20 iron ore mines or mining complexes within the Iron Quadrangle (table 2–1, figure 2–1). Iron ore is extracted from open pit mines and transported either to pelletizing plants or directly to ports for export. The largest producing among these companies is Vale S.A., which operates six mining complexes within the Iron Quadrangle and has produced ore from more than 19 mines during the course of the company's operating history in the region.

Vale's six mining complexes are the Itabira, Itabirito, Mariana, Minas Centrais, Paraopeba, and Vargem Grande complexes, which are subsequently organized into two systems, the Southeastern System (Itabira, Minas Centrais, and Mariana complexes) and the Southern System (Itabirito, Paraopeba, and Vargem Grande complexes). Proven and probable iron ore (Fe_2O_3) reserves total nearly 5.5 Gt at an average 44 percent grade in the Southern System and 5.0 Gt at an average 46 percent grade in the Southeastern System. In 2015, Vale reported that its mines in the Iron Quadrangle accounted for about 60 percent of the company's annual iron ore production of 333 Mt from Brazil (note: this total does not include production from Samarco, of which Vale owns a 50 percent interest;Vale S.A., 2016a, p. 27–28, 65; 2016b).

Samarco Mineração S.A., jointly owned by Vale (50 percent) and BHP Billiton plc (50 percent, Australia), operates the Alegria Mine and Germano concentrator, which have an annual capacity to process 22 Mt of iron ore. Operations at the Germano Mine commenced in 1977, but have since closed owing to depletion of ore in 1991. The Alegria Mine, which commenced production in 1992, supplies the Germano concentrator with iron ore. Vale acquired 50 percent of Samarco in 2000 through its acquisition of S.A. Mineração da Trindade (Samitri). At the time of the acquisition Samarco was jointly controlled by Samitri (5 percent) and BHP Billiton (49 percent). As part of the Vale acquisition, Samitri sold 1 percent of its share of Samarco to BHP Billiton, equalizing the partner's ownership interests (BHP Billiton Ltd., 2002, p. 28; Vale Overseas Ltd., 2002, p. 16; Vale S.A, 2016b).

Mineração Usiminas S.A. [Usinas Siderúrgicas de Minas Gerais S.A. (Usiminas), 70 percent and Sumitomo Corp., 30 percent] operates four mines in the western section of the Iron Quadrangle, known as the Serra Azul region, with a combined annual capacity of 12 Mt of iron ore. Usiminas acquired the mines in the region through its 2008 acquisition of Brazilian mining companies Siderúrgica Oeste de Minas Ltda. and Global Mineração Ltda. Usiminas formed Mineracao Usiminas S.A. in 2010 as a partnership with Sumitomo Corp. (Usinas Siderúrgicas de Minas Gerais S.A., 2009, p. 38; 2011, p. 10). MMX Mineração e Metálicos S.A. owns and operates two mines within the Serra Azul region of the Iron Quadrangle: the Tico-Tico and Ipe mines. MMX acquired the Tico-Tico Mine in 2007 and the Ipe Mine in 2008 (MMX Mineração e Metálicos S.A, undated).

Pelletizing plants

Vale operates two pelletizing plants located within the Iron Quadrangle, one at the Itabiritos complex, known as the Fabrica pelletizing plant, and the other at the Vargem complex, known as Vargem Grande. Vale also owns eight pelletizing plants located at its port of Tubarão in Espírito State, which processes ore sourced from Vale's Southeastern System mines. Samarco operates three pelletizing plants located at the Port of Ubu (Ponta Ubu), Espírito Santo State. The pelletizing plants at Ponta Ubu process ore sourced from Samarco mining operations in the Iron Quadrangle. Companhia Hispano-Brasileira

Table 2–1. Iron ore mining companies within the Iron Quadrangle region, Minas Gerais, Brazil.

[%, percent]

Operating company	Owner(s)	Mining complex(es) (individual mines)
ArcelorMittal Brasil S.A.	ArcelorMittal	Andrade Mine, Serra Azul Mine.
CSN Mining	CSN S.A.	Casa de Pedra Mine.
Ferrous Resources Ltda. (Ferrous Recursos Ltda.)	Ferrous Resources Ltda. (Ferrous Recursos Ltda.)	Esperança Mine, Santanense Mine, Viga Mine.
Itaminas Comercio de Minerios S.A.	Itaminas Comercio de Minerios S.A.	Itaminas Mine.
Mineração Itauna Ltda.	Mineração Itauna Ltda.	Minerita Mine.
Mineração Usiminas S.A.	Mineração Usiminas S.A.	Central Mine, Eastern Mine, Pau de Vinho Mine, Western Mine.
MMX Sudeste Mineração e Metalicos S.A.	MMX Mineração e Metalicos S.A.	Ipe Mine, Tico-Tico Mine.
Samarco Mineração S.A.	Vale (50%) and BHP Billiton plc (50%)	Alegria Mine, Germano concentrator (at now-closed Germano mine site).
Vale S.A.	Vale S.A.	Itabira Mine, Itabirito Mine, Mariana Mine, Minas Centrais, Paraopeba, Vargem Grande.

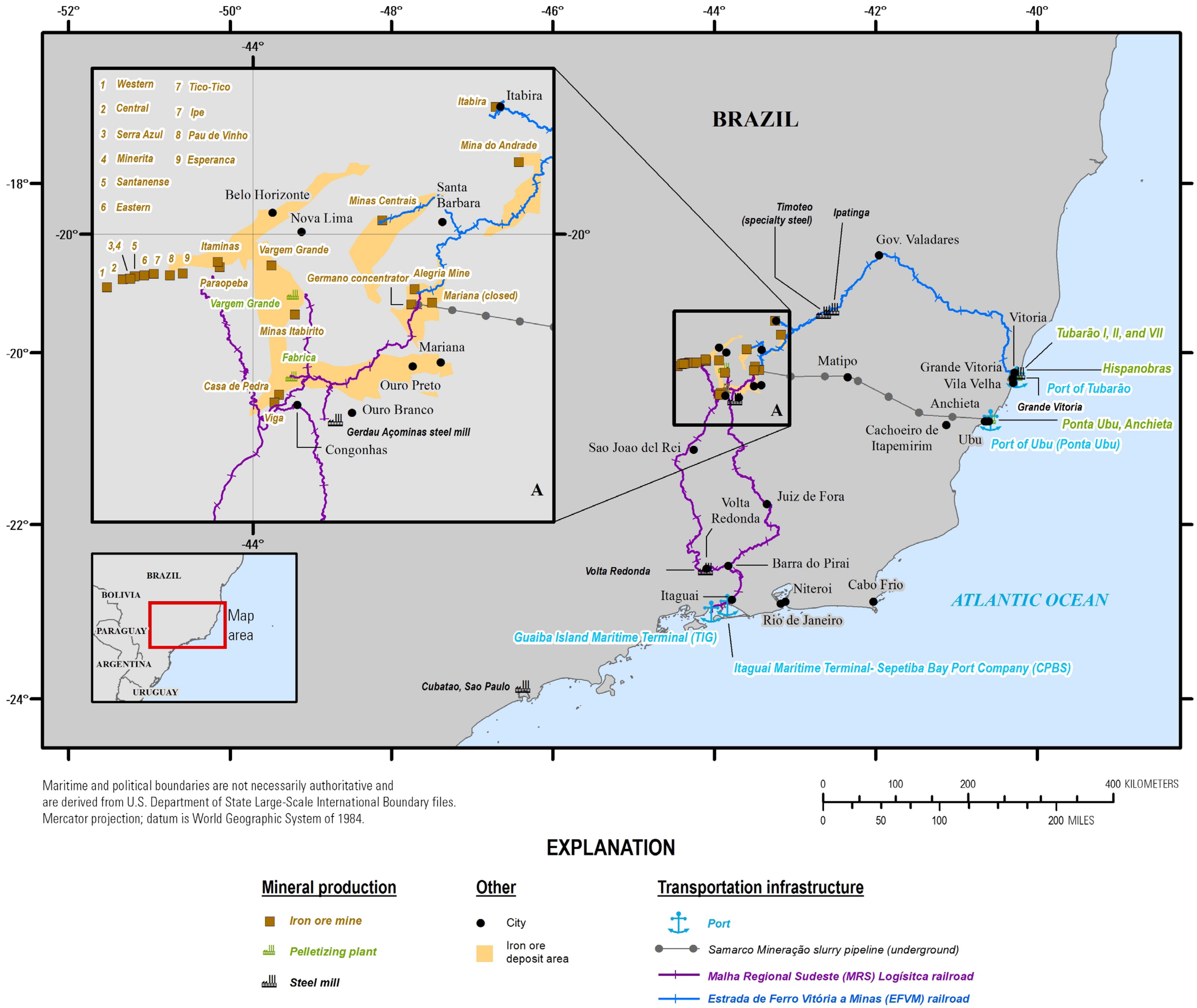


Figure 2–1. Overview map of iron ore mines, pelletizing plants, steel mills, and associated transportation infrastructure in the Iron Quadrangle, Minas Gerais, Brazil, 2015.

de Pelotização S.A (HISPANOBRAS), jointly owned by Vale (50.9 percent) and ArcelorMittal (49.1 percent), operates a pelletizing plant in Vitória, Espírito Santo State, adjacent to the port of Tubarão (Companhia Hispano-Brasileira de Pelotização S.A., 2014, p. 7; Vale S.A., 2016c, p. 30; 2016b).

Transportation infrastructure

Two railroad companies serve the iron ore industry in the Iron Quadrangle region, the EFVM and MRS Logística S.A. Vale operates EFVM under a 30-year renewable concession that expires in 2027. Iron ore sourced from Vale's Southeastern System mines is transported by EFVM to Vale's pelletizing plants in Vitória. The EFVM also transports port passengers from Vitória to the capital of Minas Gerais, Belo Horizonte (Vale S.A., 2016a, p. 56; 2016b). MRS Logística is owned by a partnership between Companhia Siderúrgica Nacional S.A. (CSN), Gerdau S.A., Usiminas Particpacoes e Logística (subsidiary of Mineração Usiminas), and Vale. The MRS Logística railway connects iron ore facilities in the Iron Quadrangle to ports in Rio de Janerio State. Iron ore and pellets from Vale's Southern System mines are transported via the MRS Logística railway to Vale's Guaiba Island Maritime Terminal and the Itaguai Maritime Terminal (operated by Vale's wholly owned subsidiary Cia. Portuaria Baia Sepetiba). MRS Logística transports ore sourced by CSN's Casa de Pedra Mine to CSN's fully owned terminal located adjacent to Vale's Itaguai Maritime Terminal. Ore sourced from MMX-owned mines is also transported to the CSN-owned terminal, as well as to the newly opened terminal operated by Porto Sudeste do Brasil S.A., jointly owned by a partnership between Impala Terminals (wholly owned subsidiaries of Trafigura Group) and Mubadala Development Company PJSC (65 percent) and MMX (35 percent) (MMX Mineração e Metálicos S.A, undated; Porto Sudeste do Brasil S.A., 2016; Vale S.A., 2016a, p. 27–28).

Iron ore sourced from Samarco's Alegria Mine is first transported for grinding to the nearby Germano concentrator. The ore is then transported more than 350 km using three separate underground slurry pipes that connect the Germano concentrator and Samarco's pelletizing plants at Ponta Ubu. The first of these pipelines was installed in 1977; construction on the second pipeline began in 2005 and was completed in 2008. A third pipeline was installed in 2014 as the production of the Samarco mining operations continued to expand (Ausenco Ltd., 2016; Samarco Mineração S.A., 2016; Vale S.A., 2016a, p. 28). Slurry pipelines were significantly damaged in the Fundão tailings dam collapse in November 2015 (McCrae, 2016).

Appendix 3—Case study 2: Bauxite mining and alumina production in Jamaica

Geologic overview

The USGS classified bauxite deposits in Jamaica as pocket deposits, which are defined primarily as the fillings within depressions in limestones or dolomites that vary greatly in both shape and size. The irregularly shaped bauxite deposits have diameters that range from 15 m to more than 100 m and thicknesses that range from less than 1 m to more than 30 m. The soils overlying these pocket deposits are rarely more than 1 m thick and can easily be stripped away without the use of drilling and blasting. The pocket deposits in Jamaica formed over the undulating surface of the White Limestone Formation, with bauxite filling sinkholes and extending over limestone ridges between sinkhole formations (Patterson and others, 1986, p. B10, B17–B18, B52–B53).

Country background

Bauxite production in Jamaica began in 1952, and within six years the country became the world's leading bauxite producer. In 2015, Jamaica ranked sixth in world bauxite production, producing about 10.7 Mt, which accounted for about 4 percent of the world's total bauxite production. Bauxite reserves in Jamaica were estimated to be about 2 Gt in 2015, which ranks Jamaica second in the Latin America and Caribbean region, behind Brazil, and fifth in the world. Jamaica produced about 1.95 Mt of alumina in 2015, which accounted for about 1.7 percent of the world's alumina production.

Companies engaged in the production of bauxite and alumina in Jamaica include (1) Jamaica Aluminum Co. (Jamalco), which is 55 percent owned by Noble Group Ltd. of China and 45 percent owned by Clarendon Alumina Production (wholly owned by the Government of Jamaica); (2) Noranda Jamaica Bauxite Partners LLC, owned 51 percent by the Government of Jamaica and 49 percent by Noranda Aluminum Holding Corp. of Canada; and (3) United Company RUSAL of Russia through its two wholly owned subsidiaries, Alumina Partners of Jamaica (Alpart) and West Indies Alumina Co. (Windalco) (Bray, 2016c, p. 10.13; Jamaica Bauxite Institute, 2015b; Patterson and others, 1986, p. B52; Soto-Viruet, 2015a, p. 13.8; United Company RUSAL Plc, 2015).

All of Jamaica's bauxite and alumina is exported, as the country does not have the infrastructure to support the production of primary aluminum metal. The value of bauxite and alumina exports from Jamaica in 2015 was about $130 million and $542 million, respectively. Together, bauxite and alumina exports accounted for 53 percent of Jamaica's total value of exports in 2015, up from 46 percent in 2014 and 41 percent in 2013 (Bank of Jamaica, 2016, p. 2).

Historical perspective

Bauxite in Jamaica was first identified in the late 1930s on a farm in Lydford, St. Ann Parish, when soil fertility tests indicated the soil was highly aluminous. This discovery triggered an interest by European and North American aluminum companies. The first company to explore Jamaica for bauxite following the initial discovery was the Aluminum Co. of Canada, Ltd. (now Rio Tinto Alcan, Inc.). The Aluminum Co. of Canada constructed the Kirkvine Works, Jamaica's first alumina refinery, in 1952, and the country's second alumina refinery, the Ewarton Works, in 1959. United States-based companies Reynolds Metals Co. (acquired by Alcoa Inc. in 2000) and Kaiser Aluminum Corp. began exporting bauxite from a port in Ocho Rios on the eastern coast of St. Ann Parish in 1952 and from Port Kaiser in 1953, respectively. The Ocho Rios port is no longer operational, with the only northern coast transportation infrastructure located at Discovery Bay/Port Rhoades.

In 1957, five years after the opening of the Kirkvine Works, Jamaica had become the world's largest producer of bauxite and alumina. Alcoa was the fourth company to enter the bauxite and alumina market and began exporting bauxite in 1961. In 1969, Alumina Partners of Jamaica (Alpart) was established as a partnership between Kaiser Aluminum, Reynolds Metals, and the Anaconda Copper Mining Co., and commissioned the construction of the Nain alumina refinery. Revere Copper and Brass Co. constructed the country's fourth alumina refinery in Maggotty, St. Elizabeth Parish, in 1971. Alcoa constructed the Halse Hall refinery in 1973 (also known as the Clarendon Alumina Works), the fifth alumina refinery to operate in Jamaica. Jamaica stayed first in world production until 1971 (Jamaica Bauxite Institute, 2015d; Wilmot and others, 1959).

In the 1970s the Jamaican Government established (1) Jamaica Bauxite Mining (JBM), for the purpose of holding assets acquired from government/private partnerships and joint ventures; (2) the Jamaica Bauxite Institute (JBI), for the purpose of advising, monitoring, and implementing policies on all aspects of the bauxite and alumina industry; and (3) the Bauxite and Alumina Trading Co., for the purpose of carrying out all trading activities on behalf of government-owned entities. Jamalco was formed in 1976, as a partnership between Alcoa (94 percent) and JBM (6 percent), and began to export bauxite through the port at Rocky Point in Clarendon Parish. The Jamaican Government formed Clarendon Alumina Production (CAP) in 1988 and acquired 44 percent of Alcoa's shares of Jamalco in order to continue operations at the Halse Hall/Clarendon refinery, which had closed in the same year. In 1985, the Jamaican Government acquired

Reynolds Metals operations, which had closed in 1984. The Alpart operation closed in 1985, but reopened in 1988 under a new joint venture between Kaiser Aluminum (65 percent) and Norwegian-based Hydro Aluminum (35 percent). In 2001, Glencore International AG of Switzerland acquired Alcan Inc.'s (formerly Aluminum Company of Canada) 93-percent share in the Ewarton and Kirkvine alumina refineries, with the remaining 7 percent owned by JBM. JBM and Glencore formed the joint venture West Indies Alumina Co. (Windalco) to manage the Ewarton and Kirkvine refineries and the bauxite mines in Russell Place and Schwallenburgh (Bermúdez-Lugo, 2004). In 2007, RUSAL acquired Glencore's 93 percent share in Windalco and in 2014 acquired JBM's remaining 7 percent share in Windalco (Jamaica Bauxite Institute, 2015c–d; The Gleaner, 2014). In 2014, Alcoa World Alumina and Chemicals (AWAC) completed the sale of its 55-percent interest in Jamalco to Noble Group Ltd. of China, after receiving all regulatory approvals; AWAC would remain the managing operator until 2017 (Alcoa Inc., 2014).

Mineral production facilities and transportation infrastructure

Mines and alumina refineries

The majority of bauxite mining in Jamaica takes place in Manchester and St. Ann parishes, with some mining extending into the adjacent St. Elizabeth and St. Catherine parishes (figure 3–1).

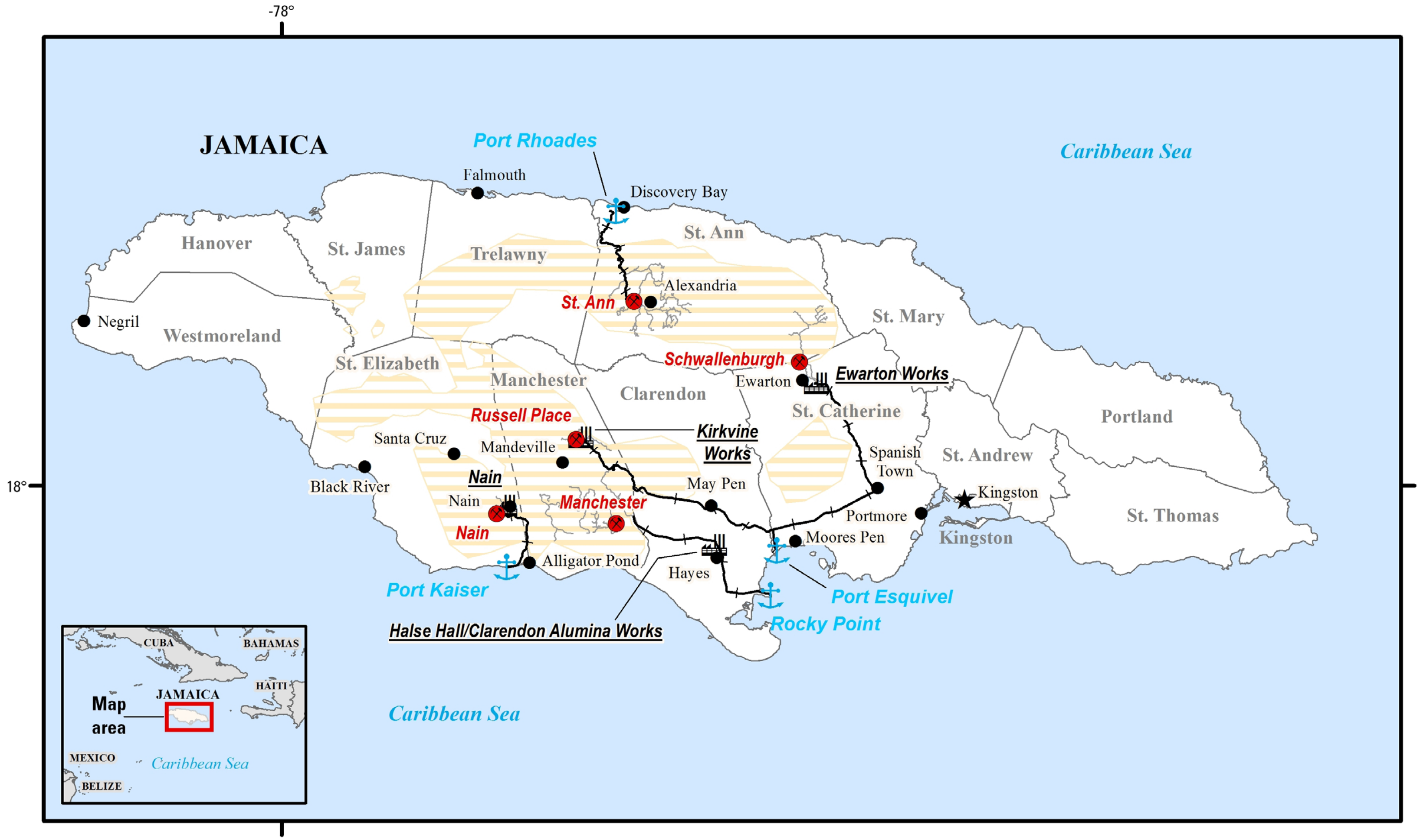
Bauxite ore is hauled by truck and conveyor belt from mining sites and then transported to a domestic alumina refinery or transported by rail directly to a port for export. As of 2016, there were four alumina refineries having the physical infrastructure to process bauxite into alumina; however, not all were operational. The Ewarton Works in St. Catherine Parish (operated by Windalco) and the Clarendon Alumina Works in Clarendon Parish (operated by Jamalco) were both in operation. Windalco's Kirkvine Works has been suspended from processing alumina since 2009. The fourth alumina refinery, at Nain in St. Elizabeth Parish—sometimes referred to as the Alpart refinery—closed in 2009 and was sold to Jinquan Iron and Steel Co. in 2016 (The Gleaner, 2016).

Bauxite and alumina are exported from Jamaica by way of four ports, three on the southern coast and one on the northern coast. In the south, rail lines transport (1) bauxite and alumina produced by Windalco to Port Esquivel in St. Catherine Parish, (2) alumina produced by Jamalco's Clarendon Alumina Works to Rocky Point port in Clarendon Parish, and (3) bauxite mined by Alpart near Nain to Port Kaiser in St. Elizabeth Parish. In the north, bauxite mined by Noranda at the St. Ann bauxite operation is transported by rail to Discovery Bay/Port Rhoades (Jamaica Bauxite Institute, 2015a–b; Myers, 2015; Patterson and others, 1986, p. B10).

The St. Ann bauxite mining operation in St. Ann Parish, operated by Noranda, has the capacity to produce 5.4 Mt (dry) of bauxite per year. Noranda reports that the mining at the operation is performed primarily by contracted third parties furnishing their own equipment. About 2.6 Mt of the bauxite mined annually at the St. Ann operation is exported to Noranda's alumina refinery at Gramercy, Louisiana, United States, while the remaining bauxite is sold to third parties (Jamaica Bauxite Institute, 2015a; Noranda Aluminum Holding Corp., 2015, p. 2, 9).

RUSAL's wholly owned subsidiary, Alpart, operates a bauxite mine near Nain, St. Elizabeth Parish, having an annual capacity of 4.9 Mt. Operations at this mine resumed in 2015 following the 2009 closure of the mine and adjacent refinery, also owned by Alpart. The inactive Alpart alumina refinery in Nain had an annual capacity of 1.65 Mt. Bauxite mined by Alpart is exported to RUSAL's Nikolaev alumina refinery in Ukraine. RUSAL's other wholly owned subsidiary in Jamaica, Windalco, operates the Ewarton Works and Kirkvine Works alumina refineries, which have a combined annual capacity of 1.21 Mt. Bauxite is supplied to these refineries by two Windalco-owned and -operated mines, the Russell Place Mine and the Schwallenburgh Mine. The Russell Place Mine supplies the adjacent Kirkvine Works, while the Schwallenburgh Mine, which extends northward into St. Ann Parish, supplies the Ewarton Works. These two bauxite mines have a combined annual capacity of 4 Mt (Jamaica Bauxite Institute, 2015b; Myers, 2015; United Company RUSAL Plc, 2016, p. 23–24).

The Clarendon Alumina Works in Halse Hall, Clarendon Parish, operated by Jamalco, has an annual capacity of about 1.4 Mt. Bauxite is supplied to the refinery via rail from Jamalco's Manchester Mine in south Manchester Parish. Alumina produced by the refinery is then transported about 20 km by rail to the Rocky Point port in Clarendon Parish, where it is exported to Canada, Iceland, and mainland Europe (Jamalco Inc., 2014; Noble Group, Ltd., 2016, p. 31–33).



Parish boundaries from open-source files from University of Minnesota.
Political boundaries are not necessarily authoritative.
Mercator projection; datum is World Geographic System of 1984.

0 12.5 25 50 KILOMETERS
0 5 10 20 MILES

EXPLANATION

Mineral production

- Bauxite mine
- Alumina refinery

Other

- City
- Capital
- Bauxite deposit area
- Parish boundary

Transportation infrastructure

- Port
- Railroad
- Mining area road

Figure 3–1. Overview map of bauxite mines and alumina refineries in Jamaica, 2016, showing associated transportation infrastructure.

Manuscript approved on June 21, 2017

For more information about this publication contact:
National Minerals Information Center
U.S. Geological Survey
12201 Sunrise Valley Drive
988 National Center
Reston, VA 20192
Email: nmicrecordsmgt@usgs.gov
For additional information visit https://minerals.usgs.gov/minerals

Prepared by the U.S. Geological Survey Science Publishing Network
Reston Publishing Service Center
Edited by James R. Estabrook
Layout by Kay P. Naugle
Web support by Angela E. Hall

Baker and others—**Compilation of Geospatial Data for the Mineral Industries and Related Infrastructure of Latin America and the Caribbean**—Open-File Report 2017–1079

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20171079