

USGS mineral review

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In 2023, the estimated total value of nonfuel mineral production in the United States increased by 4 percent, in nominal terms, to \$105 billion, from the revised value of \$101 billion in 2022. The estimated value of metals produced domestically decreased slightly to \$34.9 billion, and the estimated value of industrial minerals produced domestically increased by 7 percent to \$69.9 billion (Table 1).

Increases in production of some nonfuel mineral commodities and increases in prices of some industrial minerals contributed to the total value of domestic nonfuel mineral production increasing in 2023. For the industrial minerals sector, increased construction and materials for energy and infrastructure projects as well as other manufacturing sectors led to increased production value. The largest percentage increases in production value were in bromine, helium, iodine, peat, pumice, sand and gravel (industrial), stone (crushed) and vermiculite. For the metal sector, production decreased

for several mineral commodities and prices decreased for several metals due to oversupply. Cobalt, copper, lithium, nickel, palladium, rare earths and zinc had some of the largest percentage decreases in production value.

Mineral industry performance

Discussion of mine production is commonly segmented according to the type of materials produced within the broad categories of metals and industrial minerals (also known as nonmetallic minerals). Industrial minerals can be further subdivided as natural aggregates and other industrial minerals. Metals tend to have higher unit values but lower production quantities compared with those of industrial minerals, such as crushed stone or construction sand and gravel, which have higher production quantities but lower unit values. Therefore, for discussion and analysis of the performance of the nonfuel minerals industry, the value of production is used rather than the tonnage

*All data are based on information available as of, or prior to, Jan. 31, 2024. Data source: U.S. Geological Survey, 2024, Mineral Commodity Summaries 2024: U.S. Geological Survey, <https://doi.org/10.3133/mcs2024>

**All measurements are expressed in metric unless otherwise indicated.

Table 1

U.S. mineral industry trends. (Sources: U.S. Geological Survey, U.S. Department of Energy and U.S. Department of Labor)

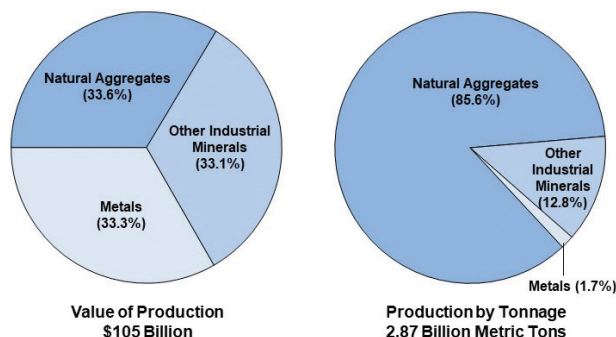
	2019	2020	2021	2022	2023*
Total mine production (million dollars):					
Metals	26,900	27,600	36,900	35,400	34,900
Industrial minerals	56,500	54,000	58,200	65,300	69,900
Coal	25,500	16,800	21,000	32,300	31,700
Employment (thousands of workers):					
Coal mining, all employees	51	40	38	40	41
Nonfuel mineral mining, all employees	140	136	138	143	150
Chemicals and allied products, production workers	559	537	541	570	570
Stone, clay and glass products, production workers	312	296	300	315	310
Primary metal industries, production workers	301	272	270	282	290
Average weekly earnings of workers (dollars):					
Coal mining, all employees	1,617	1,517	1,618	1,762	1,800
Chemicals and allied products, production workers	1,066	1,065	1,103	1,119	1,200
Stone, clay, and glass products, production workers	968	981	1,017	1,086	1,100
Primary metal industries, production workers	1,027	1,006	1,073	1,172	1,200

*Estimated.

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Figure 1

Evaluation of the performance of the minerals industry by sector. In terms of the value of production, the three segments shown are relatively similar in their contribution to the U.S. economy. If measured by tonnage, natural aggregates dwarf the performance of the other sectors.



produced. Tonnages of natural aggregates are orders of magnitude greater than those for most other mineral commodities, thus making direct comparisons based on weight less useful than value comparisons (Fig. 1).

As shown in Fig. 2, minerals are fundamental to the U.S. economy, contributing to the real gross domestic product at several levels, including mining, processing and manufacturing finished products. Net exports of mineral raw materials and old scrap were \$4.7 billion and \$17 billion, respectively. Domestic raw materials, along with domestically recycled materials, were used to produce mineral materials worth

\$890 billion. These mineral materials, including aluminum, brick, cement, copper, fertilizers and steel, along with net imports of processed mineral materials (worth about \$102 billion) were, in turn, consumed by downstream industries with value added to the gross domestic product estimated to be \$3,840 billion, a 6 percent increase from the revised value in 2022.

In 2023, domestic production of 14 mineral commodities was valued at more than \$1 billion each. These were, in decreasing order of value, crushed stone, construction sand and gravel, cement, gold, copper, iron ore, industrial sand and gravel, salt, lime, zinc, phosphate rock, soda ash, molybdenum and helium.

In 2023, 10 states had more than \$3 billion worth of publishable nonfuel mineral commodities production value and another 13 states had more than \$1.5 billion. The publishable mineral production of these 23 states, combined, accounted for about 80 percent of the total nonfuel mineral production value (Fig. 3).

Based on total nonfuel mineral production value, including withheld data, the top 10 states were, in descending order of production value, Texas, Arizona, Nevada, Minnesota, California, Florida, Alaska, Michigan, Wyoming and Missouri (Table 2).

In 2023, the United States continued to

rely on foreign sources for many raw and processed mineral materials. Imports supplied more than 50 percent of apparent consumption for 49 nonfuel mineral commodities, and the United States was 100 percent net import reliant for 15 of those (Fig. 4). Figure 5 shows the countries from which the majority of nonfuel mineral commodities with greater than 50 percent net import reliance were imported and the ranges of the number of nonfuel mineral commodities for which each country was a leading supplier. China and Canada supplied the largest number of these nonfuel mineral commodities. The countries that were the leading sources of imported mineral commodities with greater than 50 percent net import reliance were China,

Figure 2

The role of nonfuel minerals in the U.S. economy in 2023 (estimated values). (Sources: U.S. Geological Survey and U.S. Department of Commerce)

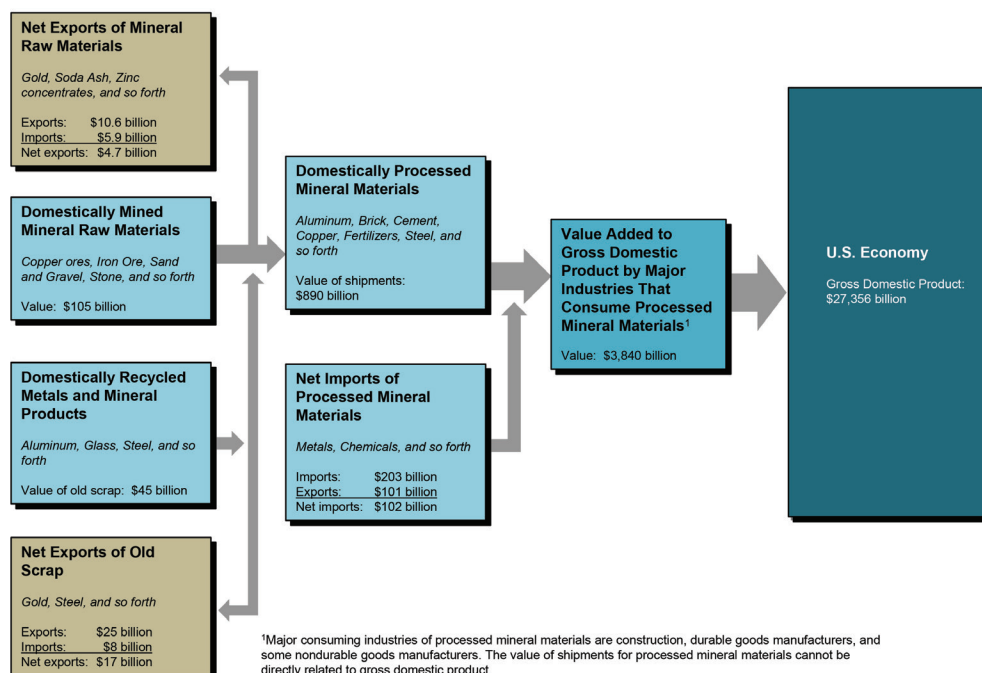
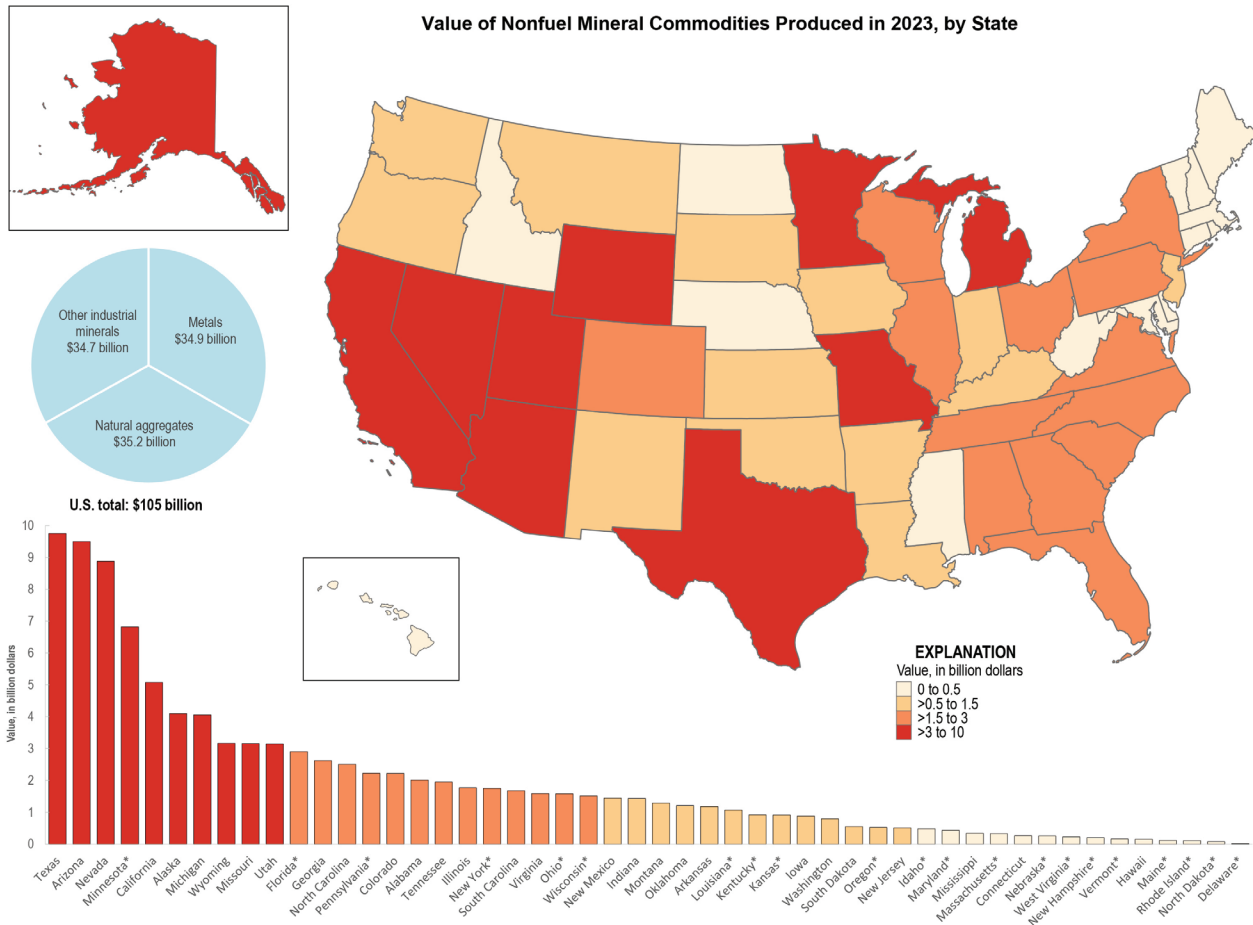


Figure 3

Map of the United States indicating the value of nonfuel mineral production by state in 2023, with charts ranking the states and proportions of production, by type of material.



*Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included with "Undistributed" in table 2.

24 mineral commodities; Canada, 23; Germany, 12; Brazil, 10; and Belgium, Mexico, Russia and South Africa, eight each. Of the more than 90 nonfuel mineral commodities evaluated, the United States was a net exporter of 20 mineral commodities.

The Defense Logistics Agency (DLA) Strategic Materials is responsible for the operational oversight of the National Defense Stockpile (NDS) of strategic and critical materials. Managing the security, providing environmentally sound stewardship and ensuring the readiness of all NDS stocks is the mission of the DLA Strategic Materials. The NDS currently contains 50 unique commodities stored at nine locations within the continental United States. In fiscal year 2023, the NDS added four materials along with additional quantities of four other materials, and approximately \$41.17 million of excess materials were sold.

Foreign trade

In April 2023, a 200 percent ad valorem tariff on aluminum articles and derivative aluminum

articles from Russia was put in place. In May 2023, the suspension of the 25 percent ad valorem tariffs imposed under section 232 of the Trade Expansion Act of 1962 for steel articles and derivative steel articles from Ukraine was extended for another year.

In 2023, the additional tariffs placed on imports from China remained while the Office of the United States Trade Representative (USTR) was conducting its four-year review of the actions imposed under section 301(b) of the Trade Act of 1974 (19 U.S.C. 2411, as amended): China's acts, policies and practices related to technology transfer, intellectual property and innovation.

In December 2023, China implemented export bans and export restrictions on certain strategic materials and technologies in the "Catalogue of Technologies Prohibited and Restricted from Export in China." Export bans prohibited any materials or technology from leaving China. Those items under an export ban included a category called "Nonferrous Metal Smelting and Processing Industry." Export restrictions required exporters to

Table 2

Value of nonfuel mineral production in the United States and principal nonfuel mineral commodities produced in 2023.^{p,1,2}

State	Value (millions)	Rank ³	Percent of U.S. total ⁴	Principal nonfuel mineral commodities ⁵
Alabama	\$2,010	18	1.92	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Alaska	4,100	7	3.91	Gold, lead, sand and gravel (construction), silver, zinc.
Arizona	9,500	2	9.07	Cement, copper, molybdenum mineral concentrates, sand and gravel (construction), stone (crushed).
Arkansas	1,180	30	1.12	Bromine, cement, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
California ⁶	5,080	5	4.85	Boron minerals, cement, rare earths, sand and gravel (construction), stone (crushed).
Colorado	2,220	15	2.12	Cement, gold, molybdenum mineral concentrates, sand and gravel (construction), stone (crushed).
Connecticut	264	43	0.25	Sand and gravel (construction), stone (crushed), stone (dimension).
Delaware ⁷	17	50	0.02	Magnesium compounds, sand and gravel (construction), stone (crushed).
Florida ^{6,7}	2,900	6	2.77	Cement, clay (attapulgite and kaolin), phosphate rock, sand and gravel (construction), stone (crushed).
Georgia ⁶	2,620	12	2.50	Cement, clay (common clay, kaolin, montmorillonite), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Hawaii	154	46	0.15	Sand and gravel (construction), stone (crushed).
Idaho ⁷	482	32	0.46	Lead, phosphate rock, sand and gravel (construction), silver, stone (crushed).
Illinois	1,770	20	1.69	Cement (portland), magnesium compounds, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Indiana	1,440	25	1.37	Cement, lime, sand and gravel (construction), stone (crushed), stone (dimension).
Iowa	879	33	0.84	Cement (portland), lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Kansas ⁷	915	26	0.87	Cement, helium, salt, sand and gravel (construction), stone (crushed).
Kentucky ⁷	919	27	0.88	Cement, clay (common clay), lime, sand and gravel (construction), stone (crushed).
Louisiana ⁷	1,070	31	1.02	Clay (common clay), lime, salt, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Maine ⁷	116	47	0.11	Cement, peat, sand and gravel (construction), stone (crushed), stone (dimension).
Maryland ⁷	431	35	0.41	Cement, sand and gravel (construction), stone (crushed), stone (dimension).
Massachusetts ⁷	329	41	0.31	Clay (common clay), lime, sand and gravel (construction), stone (crushed), stone (dimension).
Michigan	4,060	8	3.87	Cement, iron ore, nickel sulfide concentrates, sand and gravel (construction), stone (crushed).
Minnesota ⁷	6,820	4	6.51	Iron ore, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Mississippi	338	42	0.32	Clay (ball clay, bentonite, common clay, montmorillonite), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Missouri	3,160	10	3.01	Cement, lead, lime, sand and gravel (industrial), stone (crushed).
Montana	1,290	28	1.23	Copper, molybdenum mineral concentrates, palladium, platinum, sand and gravel (construction).

State	Value (millions)	Rank ³	Percent of U.S. total ⁴	Principal nonfuel mineral commodities ⁵
Nebraska ⁷	\$260	40	0.25	Cement (portland), lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Nevada	8,880	3	8.47	Copper, gold, lime, sand and gravel (construction), stone (crushed).
New Hampshire ⁷	203	44	0.19	Sand and gravel (construction), stone (crushed), stone (dimension).
New Jersey	515	38	0.49	Sand and gravel (construction), sand and gravel (industrial), stone (crushed).
New Mexico	1,450	24	1.38	Cement, copper, potash, sand and gravel (construction), stone (crushed).
New York ⁷	1,750	16	1.67	Cement, salt, sand and gravel (construction), stone (crushed), zinc.
North Carolina	2,500	13	2.39	Phosphate rock, quartz (high-purity), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
North Dakota ⁷	78	49	0.07	Lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Ohio ⁷	1,580	17	1.51	Cement, lime, salt, sand and gravel (construction), stone (crushed).
Oklahoma	1,210	29	1.15	Cement, iodine, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Oregon ⁷	527	36	0.50	Cement (portland), diatomite, perlite, sand and gravel (construction), stone (crushed).
Pennsylvania ⁷	2,220	14	2.12	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Rhode Island ⁷	109	48	0.10	Sand and gravel (construction), sand and gravel (industrial), stone (crushed).
South Carolina	1,680	21	1.60	Cement, gold, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
South Dakota	549	37	0.52	Cement (portland), gold, lime, sand and gravel (construction), stone (crushed).
Tennessee	1,950	19	1.86	Cement, sand and gravel (construction), sand and gravel (industrial), stone (crushed), zinc.
Texas	9,750	1	9.31	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Utah	3,140	11	3.00	Cement (portland), copper, gold, potash, salt.
Vermont ⁷	160	45	0.15	Sand and gravel (construction), stone (crushed), stone (dimension), talc (crude).
Virginia	1,590	23	1.52	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Washington	796	34	0.76	Cement, diatomite, lime, sand and gravel (construction), stone (crushed).
West Virginia ⁷	231	39	0.22	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Wisconsin ⁷	1,510	22	1.44	Lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed), stone (dimension).
Wyoming	3,170	9	3.02	Clay (bentonite and common clay), helium, sand and gravel (construction), soda ash, stone (crushed).
Undistributed	4,900	XX	4.68	XX
Total	105,000	XX	100.00	

⁶Preliminary. XX = Not applicable.

¹Includes data available through Dec. 21, 2023.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Based on total, unadjusted state values.

⁴Calculated to two decimal places.

⁵Listed in alphabetical order.

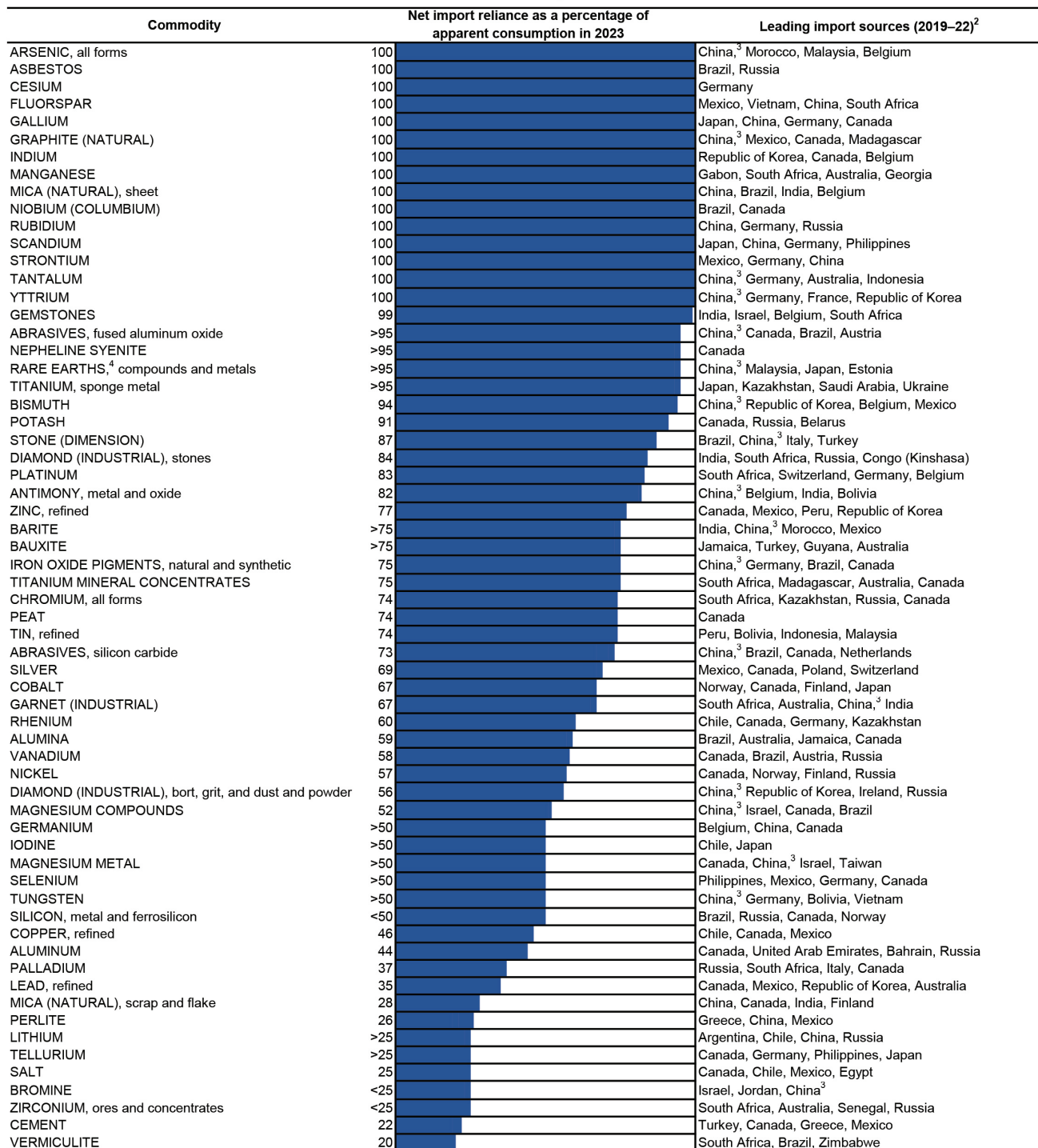
⁶California, Florida and Georgia also produce significant quantities of titanium mineral concentrates and zirconium mineral concentrates. Breakdown by state is not available to avoid disclosure of company proprietary data.

⁷Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included with "Undistributed."

Figure 4

U.S. net import reliance for selected nonfuel minerals in 2023.

2023 U.S. Net Import Reliance¹



¹Not all mineral commodities covered in this publication are listed here. Those not shown include mineral commodities for which the United States is a net exporter (abrasives, metallic; beryllium; boron; cadmium; clays; diatomite; gold; helium; iron and steel scrap; iron ore; kyanite; lime; molybdenum; rare earths, mineral concentrates; sand and gravel, industrial; soda ash; titanium dioxide pigment; wollastonite; zeolites; and zinc, ores and concentrates) or less than 20% net import reliant (feldspar; gypsum; iron and steel; iron and steel slag; nitrogen (fixed)—ammonia; phosphate rock; pumice; sand and gravel, construction; stone, crushed; sulfur; and talc and pyrophyllite). For some mineral commodities (hafnium; mercury; quartz, high-purity and industrial cultured crystal; thallium; and thorium), not enough information is available to calculate the exact percentage of import reliance.

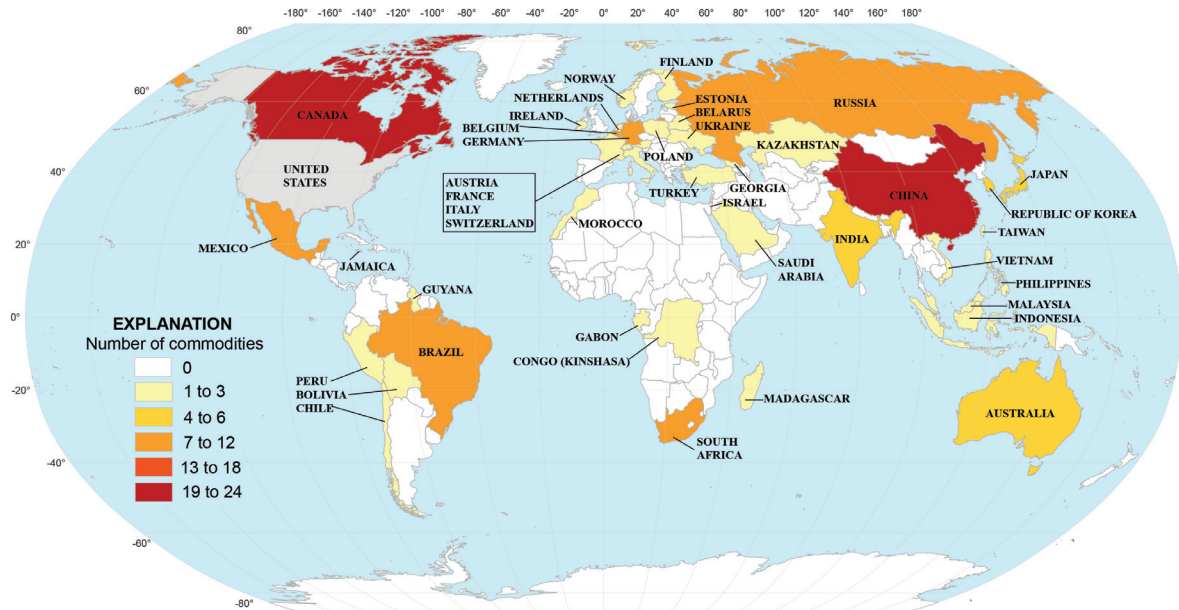
²Listed in descending order of import share.

³Includes Hong Kong.

⁴Includes lanthanides cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thulium, and ytterbium.

Figure 5

World map highlighting major import sources (2019-2022) for nonfuel mineral commodities for which the United States was more than 50 percent import dependent. The countries are color-coded to indicate the number of mineral commodities for which the country was considered a major supplier to the United States. China, followed by Canada, supplied the largest number of nonfuel mineral commodities. (Source: U.S. Geological Survey)



apply for a license, which, according to some sources, required export contracts, technical product specifications and the identity of the end user as well as the specific end use. Export restrictions included nonferrous metal mining technology, smelting and processing. China was the dominant global producer for many of the materials, and many of the materials were on the U.S. critical minerals list.

Critical minerals

On Feb. 24, 2022, pursuant to section 7002 of the Energy Act of 2020 (Public Law 116-260) and using the definition of “critical mineral” and the criteria specified therein, the U.S. Geological Survey (USGS) published the “2022 Final List of Critical Minerals” in the Federal Register (87 FR 10381). The 2022 list of critical minerals, which revised the U.S. critical minerals list (CML) published in 2018 (83 FR 23295), included 50 mineral commodities instead of 35 mineral commodities or mineral groups (Table 3). The changes in the 2022 CML from the 2018 CML were the addition of nickel and zinc, listing out individual platinum group metals and rare earth elements, and the removal of helium, potash, rhenium, strontium and uranium. The CML is to be updated at least every three years and revised as necessary, consistent with available data.

A series of actions by the government in recent years addressed domestic supply-chain vulnerabilities for critical minerals, beginning with Executive Order 13817, “A Federal

Strategy to Ensure Secure and Reliable Supplies of Critical Minerals,” which was issued on Dec. 26, 2017, and initiated a whole-of-government call to action to identify critical minerals and develop a strategy to address U.S. supply-chain vulnerabilities. Subsequently, there have been additional actions including the following:

1. The USGS published the 2018 CML.
2. The U.S. Department of Commerce with interagency input published the “2019 Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals.”
3. Several Presidential determinations directed the use of Defense Production Act (DPA) title III authorities to strengthen the U.S. industrial base for rare earth elements.
4. Executive Order 13953 was issued “Addressing the Threat to the Domestic Supply Chain Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries.”
5. The Energy Act of 2020 was passed by Congress and signed into law.

Several congressional acts and other government actions have focused on investments for clean energy projects; critical mineral mapping, production, recycling, reclamation and resource assessments; domestic production of batteries; infrastructure projects;

Table 3

The 2022 U.S. critical minerals list.¹

Critical mineral	Applications
Aluminum	Metallurgy and many sectors of the economy.
Antimony	Flame retardants and lead-acid batteries.
Arsenic	Pesticides and semiconductors.
Barite	Hydrocarbon production.
Beryllium	Aerospace and defense.
Bismuth	Medical, metallurgy, and atomic research.
Cerium ²	Catalytic converters, ceramics, glass, metallurgy, and polishing compounds.
Cesium	Research and development.
Chromium	Metallurgy.
Cobalt	Batteries and metallurgy.
Dysprosium ²	Data storage devices, lasers, and permanent magnets.
Erbium ²	Fiber optics, glass colorant, lasers, and optical amplifiers.
Europium ²	Nuclear control rods and phosphors.
Fluorspar	Cement, industrial chemicals, and metallurgy.
Gadolinium ²	Medical imaging, metallurgy, and permanent magnets.
Gallium	Integrated circuits and optical devices.
Germanium	Defense and fiber optics.
Graphite	Batteries, fuel cells, and lubricants.
Hafnium	Ceramics, nuclear control rods, and metallurgy.
Holmium ²	Lasers, nuclear control rods, and permanent magnets.
Indium	Liquid crystal displays.
Iridium ³	Anode coatings for electrochemical processes and chemical catalysts.
Lanthanum ²	Batteries, catalysts, ceramics, glass, and metallurgy.
Lithium	Batteries.
Lutetium ²	Cancer therapies, electronics, and medical imaging.
Magnesium	Metallurgy.

Critical mineral	Applications
Manganese	Batteries and metallurgy.
Neodymium ²	Catalysts, lasers, and permanent magnets.
Nickel	Batteries and metallurgy.
Niobium	Metallurgy.
Palladium ³	Catalytic converters and catalysts.
Platinum ³	Catalytic converters and catalysts.
Praseodymium ²	Aerospace alloys, batteries, ceramics, colorants, and permanent magnets.
Rhodium ³	Catalytic converters, catalysts, and electrical components.
Rubidium	Research and development.
Ruthenium ³	Catalysts, electronic components, and computer chips.
Samarium ²	Cancer treatments, nuclear, and permanent magnets.
Scandium	Ceramics, fuel cells, and metallurgy.
Tantalum	Capacitors and metallurgy.
Tellurium	Metallurgy, solar cells, and thermoelectric devices.
Terbium ²	Fiber optics, lasers, permanent magnets, and solid state devices.
Thulium ²	Lasers and metallurgy.
Tin	Metallurgy.
Titanium	Metallurgy and pigments.
Tungsten	Metallurgy.
Vanadium	Batteries, catalysts, and metallurgy.
Ytterbium ²	Catalysts, lasers, metallurgy, and scintillators.
Yttrium	Catalysts, ceramics, lasers, metallurgy, and phosphors.
Zinc	Metallurgy.
Zirconium	Metallurgy and nuclear.

¹The 2022 Final List of Critical Minerals published Feb. 24, 2022, by the U.S. Geological Survey (87 FR 10381).

²Included in the Rare Earths chapter.

³Included in the Platinum-Group Metals chapter.

research and development; ports and rail improvements; semiconductor supply-chain projects; telecommunications broadband networks and water systems. These actions have included the following:

1. Congress passed, and the President signed the \$1.2 trillion Bipartisan Infrastructure Law (Infrastructure

- Investment and Jobs Act, H.R. 3684, Public Law 117-58) in November 2021.
2. A Presidential determination on March 31, 2022, authorized the use of DPA title III authorities to strengthen the U.S. industrial base for large-capacity batteries and specifically increasing domestic mining and processing of critical materials for the large-capacity

- battery supply chain such as cobalt, graphite, lithium and nickel.
3. The Ukraine Supplemental Appropriations Act of 2022 provided \$600 million for DPA title III funds for missiles and munitions in support of Ukraine and strategic and critical materials to expand domestic capacity.
4. The CHIPS and Science Act of 2022 (Public Law 117–167) provided \$280 billion in funding over the next 10 years for domestic research, commercialization, and manufacturing of semiconductors.
5. The Inflation Reduction Act of 2022 (Public Law 117–169) was signed into law with the aim to reduce inflation. Specifically related to critical minerals, it authorized \$391 billion in funding for climate change and domestic energy production including targeted tax incentives aimed at manufacturing U.S.-sourced materials such as batteries, electric vehicles, solar and wind parts and technologies.
6. In October 2022, the “American Battery Materials Initiative” was launched to leverage and maximize ongoing efforts throughout the U.S. Government to meet resource requirements and bolster energy security.
7. In December 2022, the \$858 billion National Defense Authorization Act included a provision requiring a federal strategy be developed to recycle and recover critical minerals from batteries used in the federal electric vehicle fleet.

Several investments were announced in 2023 to address the domestic availability and supply of critical minerals. On Jan. 13, 2023, the Loan Program Office (LPO) at the U.S. Department of Energy (DOE) offered a conditional commitment to lend up to \$700 million to a company in Nevada to develop a domestic supply of lithium carbonate for electric-vehicle batteries. On April 4, 2023, the DOE announced \$16 million in funding from the Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act, H.R. 3684, Public Law 117-58 signed into law November 2021) to support projects in West Virginia and North Dakota for the development of a first-of-a-kind extraction and separation refinery for rare earth elements and other critical minerals. On June 15, 2023, the U.S. Department of Defense (DOD) awarded \$15 million to a company in Idaho to support feasibility studies to enhance the definition

and characterization of currently known cobalt resources as well as to assess requirements of a domestic cobalt refinery. On July 13, 2023, the DOE announced \$32 million in funding for projects to build facilities that produce rare earth elements and critical minerals and materials from domestic coal-based resources. Subsequently, on Aug. 21, 2023, the DOE announced \$30 million in funding to help lower the costs of the onshore production of rare earths and other critical minerals and materials from domestic coal-based resources. On July 17, 2023, the DOD awarded \$37.5 million to a graphite project in Alaska and on Nov. 29, 2023, awarded \$3.2 million to support a graphite project in Alabama. On Sept. 12, 2023, the DOD awarded \$20.6 million to advance nickel exploration and mineral resource definition at a project in Minnesota and awarded \$90 million to support the reopening of a lithium mine in North Carolina. The company in North Carolina estimated that the lithium mine would resume operations between 2025 and 2030. On Oct. 30, 2023, the DOD awarded \$12.7 million to a company in Virginia to increase titanium powder production for defense supply chains.

In November 2023, production was restarted at a high-purity granular polysilicon facility in Washington, which had been idled for four years. The material produced was to be shipped to a new fully integrated solar manufacturing facility in Georgia, scheduled to open in phases in 2024, that will produce silicon ingots wafer, and cells for solar module production. There has been no production of solar-grade wafers in the United States since 2016. Tax incentives for domestically sourced materials for renewable energy, such as solar wafers and cells, in the Inflation Reduction Act of 2022 were cited as the drivers for investments in these facilities.

In addition to critical minerals production investments, there were investments made in critical minerals recycling projects. On Feb. 9, 2023, the LPO at the DOE announced a conditional loan commitment of \$2 billion to a Nevada company for the construction and expansion of a battery materials campus that will support the growing electric-vehicle market in the United States. On Feb. 27, 2023, the LPO at the DOE announced a conditional loan commitment of \$375 million to a New York company for the construction of a lithium-ion battery resource recovery facility and to help the company expand its operations. From the fourth quarter of 2022 through 2023, DOE funding through the Bipartisan Infrastructure Law totaled \$3 billion for five domestic lithium-ion recycling facilities.

In 2023, the value of domestic primary mine production of critical minerals was \$4.1 billion, a 24 percent decrease from \$5.4 billion in 2022. Reduced prices for these mineral commodities contributed the most to the reduced value and delayed new production or restarting production of some critical minerals. A total of 13 individual mineral commodities and the rare earths group of minerals (without specification of the specific lanthanides) were produced in the United States. The United States was 100 percent net import reliant for 12 of the 50 critical minerals and more than 50 percent net import reliant for an additional 29 critical minerals (including 14 lanthanides, which are listed under rare earths). The United States had secondary production for 14 critical minerals, which resulted in net import reliance being less than 100 percent. The total value of critical minerals domestically recycled in 2023 was \$10 billion, 23 percent of the total value of domestically recycled old scrap.

China was the leading producing nation for 29 of 43 critical minerals (including 14 lanthanides, which are listed under rare earths) for which information was available to make reliable estimates. The other leading producing nations of critical minerals were Australia and South Africa with three critical minerals each and Congo (Kinshasa) with two critical minerals (Table 4). For 29 critical minerals (including 14 lanthanides, which are listed under rare earths), production was highly concentrated (50 percent or more) in a single country, of which five critical minerals had 80 percent or more of global production dominated by one country, two critical minerals with 70 percent to less than 80 percent of global production dominated by one country, 20 critical minerals (including 14 lanthanides, which are listed under rare earths) with 60 percent to less than 70 percent of global production dominated by one country, and two critical minerals with 50 percent to less than 60 percent of global production dominated by one country.

Metals

The estimated value of domestic metal mine production in 2023 was \$34.9 billion, slightly less than the revised value in 2022. Cobalt, copper, nickel, palladium, rare earth elements and zinc had some of the largest percentage decreases in production value. Principal contributors to the total value of metal mine production in 2023 were gold (29 percent), copper (28 percent), iron ore (22 percent), zinc (7 percent), and molybdenum (5 percent), all with production values of more than \$1 billion. The remaining nine percent of metal mine production value was from 14 other metals and (or) metal ore concentrates.

Ferrous metals. The estimated value of U.S. iron ore production in 2023 was \$7.5 billion, a 22 percent increase from the value in 2022. Iron ore production and trade were estimated to have increased likely owing to restocking and increased consumption for intermediate products. Mines in Michigan and Minnesota shipped 98 percent of the usable iron ore produced in the United States. Seven openpit iron ore mines (each with associated concentration and pelletizing plants) and four iron metallic plants, including direct-reduced iron and hot-briquetted iron producers, operated during the year to supply steelmaking raw materials. Almost all iron ore was concentrated before shipment. In April, one company restarted production, at a limited capacity, at a domestic mine that was idled in 2022, citing increases in steel production and designating the plant as a “swing operation” to fill needed capacity. In May, one company received approval for state mineral leases that were expected to supplement iron ore for a domestic mine formerly anticipated to idle in 2025 and extend the mine life for an additional 20 years. The United States was estimated to have produced 1.8 percent of the 2.5 Gt of global iron ore output in 2023.

The U.S. iron and steel industry produced raw steel in 2023 with an estimated value of about \$110 billion, a 15 percent decrease from \$128 billion in 2022. Pig iron and raw steel were produced by two companies operating integrated steel mills in 12 locations. Raw steel was produced by 49 companies at 105 minimills. Indiana accounted for an estimated 24 percent of total raw steel production, followed by Ohio, 12 percent; Pennsylvania and Texas, 5 percent each; no other state having more than 4 percent of total domestic raw steel production. Construction accounted for an estimated 30 percent of total domestic shipments by market classification, followed by service centers, 24 percent. In the United States, the apparent consumption of finished steel products was estimated to have decreased slightly in 2023 owing to interest rate increases that negatively affected manufacturing and residential construction. Increases in the commercial building and automotive sectors were attributed to the 2022 Inflation Reduction Act and the 2021 Bipartisan Infrastructure Law.

Nonferrous metals. The value of U.S. copper mine production decreased by 11 percent in 2023 to an estimated \$9.9 billion, production was estimated to be 1.1 million metric tons (Mt). Analysts attributed the decreased copper prices primarily to the strengthening of the U.S.

Table 4

Estimated salient critical minerals statistics in 2023¹ (metric tons, mine production, unless otherwise stated).

Critical mineral	United States				World				
	Primary production	Secondary production	Apparent consumption	Net import reliance as a percentage of apparent consumption	Primary import source (2019–22)	Leading producing country	Production in leading country	Percentage of world total	World production total
Aluminum (bauxite)	W	—	² 1,800,000	>75	Jamaica	Australia	98,000,000	25	³ 400,000,000
Antimony	—	4,000	22,000	82	China ⁴	China	40,000	48	83,000
Arsenic	—	NA	⁵ 6,400	100	China ⁴	Peru	⁶ 27,000	45	⁶ 60,000
Barite	W	—	W	>75	India	India	2,700,000	32	³ 8,500,000
Beryllium	190	NA	150	E	Kazakhstan	United States	190	58	330
Bismuth ⁷	—	80	1,400	94	China ⁴	China	16,000	80	20,000
Chromium	—	100,000	380,000	74	South Africa	South Africa	18,000,000	44	41,000,000
Cobalt	500	2,100	6,400	67	Norway	Congo (Kinshasa)	170,000	74	230,000
Fluorspar	NA	—	370,000	100	Mexico	China	5,700,000	65	8,800,000
Gallium	—	—	² 19	100	Japan	China	600	98	610
Germanium ⁷	—	NA	NA	>50	Belgium	China	NA	NA	NA
Graphite (natural)	—	—	76,000	100	China ⁴	China	1,230,000	77	1,600,000
Indium ⁷	—	—	⁵ 300	100	Republic of Korea	China	650	66	990
Lithium	W	NA	W	>25	Argentina	Australia	86,000	48	³ 180,000
Magnesium ⁷	W	100,000	² 55,000	>50	Canada	China	830,000	88	³ 940,000
Manganese	—	—	690,000	100	Gabon	South Africa	7,200,000	36	20,000,000
Nickel	17,000	W	⁸ 190,000	57	Canada	Indonesia	1,800,000	50	3,600,000
Niobium	—	NA	8,400	100	Brazil	Brazil	75,000	90	83,000
Palladium	10	42	82	37	Russia	Russia	92	44	210
Platinum	3	9	70	83	South Africa	South Africa	120	67	180
Rare earths (compounds and metals) ⁹	250	NA	8,800	>95	China ⁴	China	240,000	69	350,000
Scandium	—	—	NA	100	Japan	China	NA	NA	NA
Tantalum	—	NA	370	100	China ⁴	Congo (Kinshasa)	980	41	2,400
Tellurium ⁷	W	—	W	>25	Canada	China	430	67	³ 640
Tin	—	16,900	39,000	74	Peru	China	68,000	23	290,000
Titanium (metal) ⁷	W	W	³ 42,000	>95	Japan	China	220,000	67	³ 330,000
Tungsten	—	W	W	>50	China ⁴	China	63,000	81	78,000
Vanadium	—	5,700	14,000	58	Canada	China	68,000	68	100,000
Yttrium	NA	—	200	100	China ⁴	China	NA	NA	NA
Zinc ⁷	¹⁰ 220,000	(¹⁰)	970,000	77	Canada	NA	NA	NA	NA
Zirconium (ores and concentrates)	<100,000	NA	<100,000	<25	South Africa	Australia	500,000	31	1,600,000

E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.

¹Critical minerals as published in the Federal Register on February 24, 2022 (87 FR 10381). Not all critical minerals are listed here. Cesium, hafnium, iridium, rhodium, rubidium, and ruthenium are not shown because available information is insufficient to make estimates of U.S. or world production.²Reported consumption.³Excludes U.S. production.⁴Includes Hong Kong.⁵Estimated consumption.⁶Arsenic trioxide.⁷Refinery production.⁸Nickel in primary metal and secondary scrap.⁹Data include lanthanides cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thulium, and ytterbium.¹⁰Primary production includes both primary and secondary metal production.

dollar relative to other global currencies and concerns regarding economic growth in China and inflation. Arizona was the leading copper-producing state and accounted for an estimated 70 percent of domestic output. Copper was also mined in Michigan, Missouri, Montana, Nevada, New Mexico and Utah. In the United States, copper was recovered or processed at 25 mines (17 of which accounted for 99 percent of mine production), two primary smelters, two electrolytic refineries and 14 electrowinning facilities. Globally, the United States was the fifth-leading producer of mined copper, accounting for about 5 percent of the total in 2023.

Five lead mines in Missouri, plus four mines in Alaska and Idaho, that produced lead as a coproduct, accounted for all domestic lead mine production. The value of domestic lead mine production in 2023 was an estimated \$660 million, unchanged from 2022. Nearly all lead concentrate production has been exported since the last primary lead refinery in the United States closed in 2013. In 2023, domestic secondary smelter production of lead was 1 Mt, essentially unchanged from 2022. Nearly all secondary smelter production was recovered from old scrap, mostly lead-acid batteries.

The estimated value of zinc mined in 2023

was about \$2.4 billion, a 23 percent decrease from 2022. Zinc was mined in five states at seven mining operations by five companies. Three smelter facilities, one primary and two secondary, operated by two companies, produced commercial-grade zinc metal. Of the total reported zinc consumed, most was used in galvanizing. The United States ranked fifth in global zinc mine production, accounting for about 6 percent of the world total in 2023.

Precious metals. In 2023, domestic gold mine production was estimated to be slightly less than in 2022, and the value was estimated at \$10 billion. Gold was produced at more than 40 lode mines in 11 states, at several large placer mines in Alaska, and at numerous smaller placer mines (mostly in Alaska and in the Western States). The top 27 operations yielded about 97 percent of the mined gold produced in the United States. Nevada was the leading gold-producing state, accounting for about 73 percent of total domestic production. Commercial-grade gold was produced at about 15 refineries. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products.

In 2023, U.S. mines produced silver worth

an estimated \$760 million. Silver was produced domestically at four silver mines and as a byproduct or coproduct from 31 base- and precious-metal mines. Alaska continued as the country's leading silver-producing state, followed by Nevada. Commercial-grade silver production was reported by 24 domestic refiners. The estimated domestic uses for silver were primarily physical investment (34 percent), followed by electrical and electronics (27 percent). World silver mine production increased slightly in 2023, principally as a result of increased production from mines in Mexico and Chile as new silver mines were starting or ramping up.

One company in Montana produced platinum group metals (PGMs) with an estimated value of about \$510 million in 2023. Small quantities of primary PGMs also were recovered as byproducts of copper-nickel mining in Michigan; however, this material was sold to foreign companies for refining. Production at a domestic mine continued but was constrained owing to an incident that occurred in March 2023 and damaged equipment in a vertical shaft.

Refractory and specialty metals. The value of several refractory and specialty metals and minerals mined in the United States — including cobalt, nickel and rare earths — decreased significantly in 2023. The value of beryllium, molybdenum and titanium mined in the United States increased significantly in 2023.

In 2023, a mine in Michigan produced cobalt-bearing nickel concentrates, which were exported for processing. A company in Missouri built a flotation plant and produced nickel-copper-cobalt concentrates from historic mine tailings and was building a hydrometallurgical processing plant near the mine site. Ore extraction commenced at a cobalt-copper-gold mine in Idaho, but commissioning was suspended in March owing to low cobalt prices. Most U.S. cobalt and nickel supplies were imported or recovered from domestically produced scrap materials. Globally, cobalt is mostly mined as a byproduct of copper or nickel. Congo (Kinshasa) continued to be the world's leading source of mined cobalt, supplying 74 percent of the world cobalt mine production in 2023. China was the world's leading producer of refined cobalt, most of which was produced from partially refined cobalt imported from Congo (Kinshasa). China was the world's leading consumer of cobalt, with nearly 87 percent of its consumption used by the lithium-ion battery industry. Stainless and alloy steel and nickel-containing alloys typically account for more than 85 percent of domestic consumption of nickel, and superalloys, mainly

in aircraft gas turbine engines, was the main use for cobalt in the United States.

Domestic mine production of molybdenum decreased slightly to 34,000 t of contained molybdenum in 2023 compared with 34,600 t in 2022. The estimated average molybdic oxide price increased by 34 percent compared with 2022. The United States ranked fourth in global mine production of molybdenum, behind China, Chile and Peru. Molybdenum ore was produced as a primary product at two mines — both in Colorado — and six copper mines (four in Arizona and one each in Montana and Utah) recovered molybdenum as a byproduct.

Domestic rare earths were mined as a primary product in Mountain Pass, CA and produced as a byproduct from heavy-mineral-sands mining and processing in the southeastern United States. An estimated 43 kt of rare earths were mined in 2023, compared with 42 kt in 2022. Additionally, an estimated 250 t of mixed rare earth compounds were produced. Global mine production was estimated to have increased by 17 percent compared with 2022. The estimated value of rare earth compounds and metals imported by the United States in 2023 was \$190 million, a 7 percent decrease from \$208 million in 2022.

Domestic production of titanium mineral concentrates took place at surface mining operations in Georgia and Florida. An additional company processed existing mine tailings to recover a mixed heavy-mineral concentrate in California. Abrasive sands, monazite and zircon were coproducts of these operations. An estimated 95 percent of titanium mineral concentrates were consumed domestically to produce titanium dioxide pigment. The remaining 5 percent was used in welding-rod coatings and for manufacturing carbides, chemicals and titanium metal.

Industrial minerals

The value of output of industrial minerals and materials from mines in the United States was \$69.9 billion, 7 percent higher than in 2022. More than 6,500 companies contributed to this output, producing from more than 12,000 mines, quarries and processing facilities. Overall, in 2023, the production of industrial minerals, by tonnage, decreased slightly compared with 2022. In addition to mined materials, the United States is a major producer of industrial minerals that are recovered from processes other than mining. These materials, including iron and steel slag, nitrogen, sulfur and synthetic gypsum, contributed additional value to the industrial minerals industry.

Agricultural minerals. Overall industrial mineral use in agricultural production and consumption increased in 2023 and was dominated by nitrogen, phosphate rock, potash and sulfur, the first three of which are used in fertilizers to provide nutrients for plants. Sulfur (as sulfuric acid) is essential for processing phosphate rock, but also plays a role in plant nutrition.

In 2023, phosphate rock ore was mined at nine mines in four states and processed into an estimated 20 Mt of marketable product, valued at \$2 billion. Phosphate rock was produced in Florida, Idaho, North Carolina and Utah. Domestic production and consumption of phosphate rock were higher in 2023, owing to increased phosphoric acid and fertilizer production. Favorable weather conditions in the planting seasons helped to increase fertilizer consumption and reduce phosphate fertilizer stocks that had accumulated in 2022. World production was estimated to have decreased by about 4 percent, with China, Morocco and the United States remaining the leading producers.

In 2023, the domestic sales value of marketable potash was estimated to have decreased by 20 percent to \$570 million. The majority of U.S. production was from southeastern New Mexico, where two companies operated two underground mines and one deep-well solution mine. U.S. apparent consumption was estimated to have increased by about 4 percent compared with 2022. World potash consumption in 2023 for fertilizers was estimated to have increased to 37.1 Mt from 35.7 Mt in 2022. Global potash production decreased by an estimated 5 percent in 2023 from 2022, owing to producers drawing down potash inventories that had increased in 2022. Canada was the leading producer, accounting for about 33 percent of production, followed by Russia and China, accounting for 17 percent and 15 percent of the world total, respectively.

Nitrogen is commercially recovered from air as ammonia, which is produced by combining nitrogen in the atmosphere with hydrogen from natural gas. Nitrogen production was essentially unchanged in 2023 compared with 2022. A long period of generally stable and low natural-gas prices in the United States made it economic for companies to upgrade existing ammonia plants and construct new nitrogen facilities. The additional capacity has reduced ammonia imports. Expansion in the U.S. ammonia industry in the next five years is expected to increase capacity by about 2 percent, which includes decarbonized ammonia projects. Global ammonia capacity is expected to increase by a total of 6 percent during

the next four years. Capacity additions were expected in places with low-cost natural gas such as in central and eastern Asia, eastern Europe, and North America. As part of the capacity increase, decarbonized ammonia plants have been proposed in several countries, but mainly in North America. Consumption of ammonia for fertilizer is expected to increase by 1 percent per year depending on availability and cost, with the largest increases expected in Latin America and south Asia.

Elemental sulfur is recovered as a byproduct of natural-gas processing and petroleum refining, and byproduct sulfuric acid is recovered at nonferrous metal smelters. Total U.S. sulfur production in 2023 was estimated to be unchanged from 2022, and shipments were unchanged from those in 2022. Domestic production of elemental sulfur from petroleum refineries and recovery from natural-gas operations was unchanged from 2022. Domestically, refinery sulfur production is expected to remain about the same as refining utilization remains high. Domestic byproduct sulfuric acid is expected to remain relatively constant, unless one or more of the remaining nonferrous-metal smelters close. World sulfur production was unchanged compared with 2022. Starting in 2023, sulfur production from the Middle East owing to upgrades and new refining projects increased sulfur availability. Also, an increase in nickel production from high-pressure acid leach projects to produce battery materials will begin to increase sulfur demand.

Chemical minerals. Many factors affect production and consumption of mineral materials used predominantly in the chemicals industry, including the state of the U.S. economy in general, the severity of winter conditions that determine the consumption of salt for deicing purposes, the performance of the steel industry and its need for lime, and numerous other influences. Because several of these commodities have significant export components, for example, boron and soda ash, their domestic production also reflects the economic conditions in other regions of the world. Worldwide economic downturns or growth can have an impact on the domestic production of these export-dependent commodities.

The quantities of domestically produced minerals used in the chemical industry ranged from 42 Mt of salt (reported as sold or used) to a group of other minerals that totaled about 2 kt. In addition to salt, major chemical minerals production included lime, 17 Mt; soda ash, 11 Mt; and sulfur for chemical uses not associated with agricultural uses. The combined value for all minerals predominantly used as raw materials for

chemical products, excluding sulfur, which is not mined, was about \$9 billion in 2023, essentially unchanged from 2022. Salt was valued at \$2.6 billion; lime, \$2.6 billion; soda ash, \$1.9 billion; and other materials combined, \$1.8 billion (boron, bromine, iodine, lithium carbonate, magnesite, and magnesium compounds).

Commercial-scale lithium production in the United States was from one continental brine operation in Nevada. Lithium was also commercially produced from the brine-sourced waste tailings of a Utah-based magnesium producer. Two companies produced a range of downstream lithium compounds in the United States from domestic or imported lithium carbonate, lithium chloride and lithium hydroxide. Excluding U.S. production, worldwide lithium production in 2023 increased by 23 percent to approximately 180 kt from 146 kt in 2022 in response to strong demand from the lithium-ion battery market. Seven mineral operations in Australia, one mineral tailings operation in Brazil, two brine operations each in Argentina and Chile, two mineral operations in Canada, five mineral and four brine operations in China, and one mineral operation in Zimbabwe accounted for the majority of world lithium production. Owing to the rapid increase in demand of lithium in 2023, established lithium operations worldwide increased or were in the process of increasing production. Lithium supply security has become a top priority for technology companies in Asia, Europe and the United States. Strategic alliances and joint ventures among technology companies and exploration companies continued to be established to ensure a reliable, diversified supply of lithium for battery suppliers and vehicle manufacturers.

Construction minerals and materials.

More than 2.5 Gt of construction minerals and materials, which were dominated by cement, construction sand and gravel, and crushed stone, were mined and processed in the United States during 2023, a 3 percent decrease from 2022. Other minerals used in construction include certain types of clays, diatomite, dimension stone, gypsum, iron oxide pigments, mica, perlite, pumice and pumicite, staurolite, talc and pyrophyllite, tripoli, vermiculite and wollastonite. The estimated value of these materials was \$48 billion.

Natural aggregates (crushed stone and construction sand and gravel) were mined or processed in all 50 states and were valued at \$35.2 billion, 72 percent of the total value of construction minerals. Nearly three-

quarters of the aggregates sold were used in road construction. Of the 2.4 Gt of natural aggregates produced (3 percent less than the quantity in 2022), crushed stone accounted for 62 percent of the tonnage of aggregates and construction sand and gravel accounted for 38 percent. Consumption of natural aggregates was essentially unchanged from 2022; however, consumption decreased in residential housing because of interest rates increasing to the highest levels in 20 years, which was offset by increased demand for construction, energy and infrastructure projects as well as other manufacturing sectors. Changes in commercial and heavy-industrial construction activity, infrastructure funding, labor availability, new single-family housing unit starts, and weather affect natural aggregates production and consumption.

Cement was produced in 34 states and Puerto Rico with the four leading states (in descending order of production), Texas, Missouri, California and Florida, accounting for nearly 43 percent of U.S. production. Cement production accounted for 27 percent of the value of construction materials in 2023. Cement apparent consumption remained the same as in 2022. However, cement industry growth continued to be constrained by increased costs for energy, material and service inputs; labor and production shortages; and ongoing supply chain disruptions. Overall, the U.S. cement industry's growth continued to be constrained by closed or idle plants, underutilized capacity at others, production disruptions from plant upgrades, and relatively inexpensive imports. Regulators continued to implement measures designed to aid industry decarbonization efforts, such as green procurement strategies and research investments.

About 26 Mt of all varieties of clays, valued at about \$1.7 billion, were mined in the United States. Not all clays are used in construction. Common clay, which was used mainly for brick, cement and lightweight aggregates, accounted for 50 percent of the tonnage of all clays. Kaolin accounted for 4.4 Mt, or 17 percent of the total clay tonnage. Fillers, extenders, and binders accounted for 52 percent of kaolin use.

Other industrial minerals. The United States produced several other industrial minerals that are not listed separately in any of these categories but are essential in abrasives, absorbents, catalysts, ceramics and glass, coatings, cryogenics, fillers and extenders, filtering agents, grinding and polishing materials, hydraulic fracturing, optoelectronics, pigments and refractories. ■